# TEF6730

## Front-end for digital-IF car radio

Rev. 01 — 10 July 2006 Product data sheet

## 1. General description

The TEF6730 is a car radio tuner front-end for digital-IF reception, especially designed for co-operation with digital-IF DSP back-ends of the SAF773x and SAF778x families.

The FM tuner features single conversion to IF = 10.7 MHz and integrated image rejection; capable for FM 65 MHz to 108 MHz and weather band reception. The AM tuner features single conversion to IF = 10.7 MHz with an integrated AM front-end, capable for LW, MW and full SW reception. A combined AM/FM IF AGC amplifier provides a suitable IF signal to the ADC in IF DSP.

The device can be controlled via the fast-mode $I^2C$-bus (400 kHz) and includes autonomous tuning functions for easy control. No manual alignments are required.

## 2. Features

- FM mixer for conversion of FM RF to IF 10.7 MHz with large dynamic range, high image rejection and selectable mixer gain
- Selectable high or low injection of LO
- AGC PIN diode drive circuit for FM RF AGC with detection at RF and IF, including keyed AGC function
- RF input for weather band applications
- Integrated AM front-end LNA
- Integrated AM RF AGC for low desensitization and AGC PIN diode drive circuit with detection at RF and IF
- AM mixer for conversion of AM RF to IF 10.7 MHz
- AM/FM IF AGC amplifier with large dynamic range, gain controlled from IF DSP
- AM and FM front-end AGC information is available via the $I^2C$-bus
- Low phase noise local oscillator with reliable start-up behavior
- In-lock detection for optimized adaptive PLL tuning speed
- Programmable divider and mixer dividers for reception of FM (65 MHz to 108 MHz), weather band, AM LW, MW and full SW
- Two antenna DAAs
- Sequential state machine supporting all tuning actions including AFU for RDS
- Interfacing signals for IF AGC, FM keyed AGC, AFU and reference frequency to IF DSP for optimum system performance
- Software controlled flag outputs
- Selection of four $I^2C$-bus addresses

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# 3. Quick reference data

**Table 1. Quick reference data**

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Supply voltage** | | | | | | | |
| $V_{CCA}$ | analog supply voltage | on pins $V_{CC}$, $V_{CC(PLL)}$, $V_{CC(VCO)}$, $V_{CC(RF)}$, $V_{CC(IF)}$, FMMIXOUT1, FMMIXOUT2, AMMIXOUT1 and AMMIXOUT2 | | 8 | 8.5 | 9 | V |
| **Current in FM mode** | | | | | | | |
| $I_{CC(tot)}$ | total supply current | | | - | 85.3 | - | mA |
| **Current in AM mode** | | | | | | | |
| $I_{CC(tot)}$ | total supply current | | | - | 114.7 | - | mA |
| **Antenna Digital Auto Alignment (DAA)** | | | | | | | |
| DAA1: pin DAAOUT1[1] | | | | | | | |
| $G_{conv(DAA)}$ | DAA conversion gain | | | 0.1 | - | 2 | |
| DAA2: pin DAAOUT2[2] | | | | | | | |
| $G_{conv(DAA)}$ | DAA conversion gain | | | 0.7 | - | 1.35 | |
| **Reference frequency** | | | | | | | |
| External reference frequency, circuit inputs: pins FREF1 and FREF2 | | | | | | | |
| $f_{ext}$ | external frequency | | | - | 100 | - | kHz |
| **Tuning system; see Table 28, Table 29, Table 30 and Table 31** | | | | | | | |
| Voltage controlled oscillator | | | | | | | |
| $f_{VCO(min)}$ | minimum VCO frequency | | [3] | - | - | 130 | MHz |
| | | application according to Figure 25 | [3] | - | - | 159.9 | MHz |
| $f_{VCO(max)}$ | maximum VCO frequency | | [3] | 256 | - | - | MHz |
| C/N | carrier-to-noise ratio | $f_{VCO}$ = 200 MHz; $\Delta f$ = 10 kHz; Q = 30 | | 94 | 98 | - | dBc/√Hz |
| Timings | | | | | | | |
| $t_{tune}$ | tuning time | Europe FM/US FM band; $f_{ref}$ = 100 kHz; $f_{RF}$ = 87.5 MHz to 108 MHz | | - | 0.75 | 1 | ms |
| | | AM MW band; $f_{ref}$ = 20 kHz; $f_{RF}$ = 0.53 MHz to 1.7 MHz | | - | - | 10 | ms |
| $t_{upd(AF)}$ | AF update time | cycle time for inaudible AF update including 1 ms mute start and 1 ms mute release time | | - | 6 | 6.5 | ms |
| **AM overall system parameters[4]** | | | | | | | |
| $f_{i(RF)}$ | RF input frequency | LW | | 144 | - | 288 | kHz |
| | | MW | | 522 | - | 1710 | kHz |
| | | SW | | 2.3 | - | 26.1 | MHz |
| $f_{IF}$ | IF frequency | | | - | 10.7 | - | MHz |
| $V_{sens}$ | sensitivity voltage | (S+N)/N = 26 dB | | - | 50 | - | µV |



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**Table 1. Quick reference data** *...continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{i(RF)}$ | RF input voltage | start level of wideband AGC | | | | |
| | | data byte AGC bits WBAGC[1:0] = 00 | - | 125 | - | mV |
| | | data byte AGC bits WBAGC[1:0] = 01 | - | 100 | - | mV |
| | | data byte AGC bits WBAGC[1:0] = 10 | - | 75 | - | mV |
| | | data byte AGC bits WBAGC[1:0] = 11 | - | 35 | - | mV |
| $V_{i(RF)M}$ | peak RF input voltage | start level of narrow-band AGC; m = 0 | | | | |
| | | data byte AGC bits NBAGC[1:0] = 00 | - | 200 | - | mV |
| | | data byte AGC bits NBAGC[1:0] = 01 | - | 170 | - | mV |
| | | data byte AGC bits NBAGC[1:0] = 10 | - | 140 | - | mV |
| | | data byte AGC bits NBAGC[1:0] = 11 | - | 115 | - | mV |
| IP2 | second-order intercept point | referenced to receiver input | - | 152 | - | dBµV |
| IP3 | third-order intercept point | referenced to receiver input | | | | |
| | | Δf = 40 kHz | - | 130 | - | dBµV |
| | | Δf = 100 kHz | - | 133 | - | dBµV |
| $\alpha_{ripple}$ | ripple rejection | $V_{CC(ripple)}/V_{audio}$; $f_{ripple}$ = 100 Hz; $V_{CC(ripple)}$ = 10 mV (RMS); $V_{i(RF)}$ = 1 mV to 1 V | - | 40 | - | dB |
| **FM overall system parameters**[5] | | | | | | |
| $f_{i(RF)}$ | RF input frequency | FM standard | 65 | - | 108 | MHz |
| | | weather band | 162.4 | - | 162.55 | MHz |
| $f_{IF}$ | IF frequency | | - | 10.7 | - | MHz |
| $V_{sens}$ | sensitivity voltage | $B_{IF}$ = 170 kHz | - | 2 | - | µV |
| | | threshold extension enabled; weak signal handling enabled (SAF7730 N231) | - | 1.1 | - | µV |
| $V_{i(RF)}$ | RF input voltage | start level of wideband AGC | | | | |
| | | data byte AGC bits WBAGC[1:0] = 00 | - | 19 | - | mV |
| | | data byte AGC bits WBAGC[1:0] = 01 | - | 14 | - | mV |
| | | data byte AGC bits WBAGC[1:0] = 10 | - | 10 | - | mV |
| | | data byte AGC bits WBAGC[1:0] = 11 | - | 7 | - | mV |
| $V_{i(RF)M}$ | peak RF input voltage | start level of narrow-band AGC; m = 0 | | | | |
| | | data byte AGC bits NBAGC[1:0] = 00 | - | 17 | - | mV |
| | | data byte AGC bits NBAGC[1:0] = 01 | - | 14 | - | mV |
| | | data byte AGC bits NBAGC[1:0] = 10 | - | 11 | - | mV |
| | | data byte AGC bits NBAGC[1:0] = 11 | - | 9 | - | mV |
| IP3 | third-order intercept point | Δf = 400 kHz | - | 123 | - | dBµV |
| $\alpha_{ripple}$ | ripple rejection | $V_{CC(ripple)}/V_{audio}$; $f_{ripple}$ = 100 Hz; $V_{CC(ripple)}$ = 10 mV (RMS); $V_{i(RF)}$ = 500 µV | - | 64 | - | dB |

[1] Conversion gain formula of DAA1: $V_{DAAOUT1} = \left(1.915 \times \frac{n}{128} + 0.1\right) \times V_{tune}$ where n = 0 to 127.



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[2] Conversion gain formula of DAA2: $V_{DAAOUT2} = \left(0.693 \times \frac{n}{16} + 0.7\right) \times V_{DAAOUT1}$ where n = 0 to 15.

[3] The VCO frequency is determined by the external circuit at pins OSCFDB and OSCTNK.

[4] Based on 15 pF/60 pF dummy aerial, voltages at dummy aerial input, $f_{mod}$ = 400 Hz, 2.5 kHz audio bandwidth, $f_{i(RF)}$ = 990 kHz, m = 0.3 and nominal maximum IF AGC gain, unless otherwise specified.

[5] Based on 75 Ω dummy aerial, voltages at dummy aerial input, $f_{mod}$ = 400 Hz, de-emphasis = 50 µs, $f_{i(RF)}$ = 97.1 MHz, Δf = 22.5 kHz, nominal mixer gain and nominal maximum IF AGC gain, unless otherwise specified.

# 4. Ordering information

**Table 2. Ordering information**

| Type number | Package | | |
|---|---|---|---|
| | Name | Description | Version |
| TEF6730HW | HTQFP64 | plastic thermal enhanced thin quad flat package; 64 leads; body 10 x 10 x 1 mm; exposed die pad | SOT855-1 |



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## 5. Block diagram

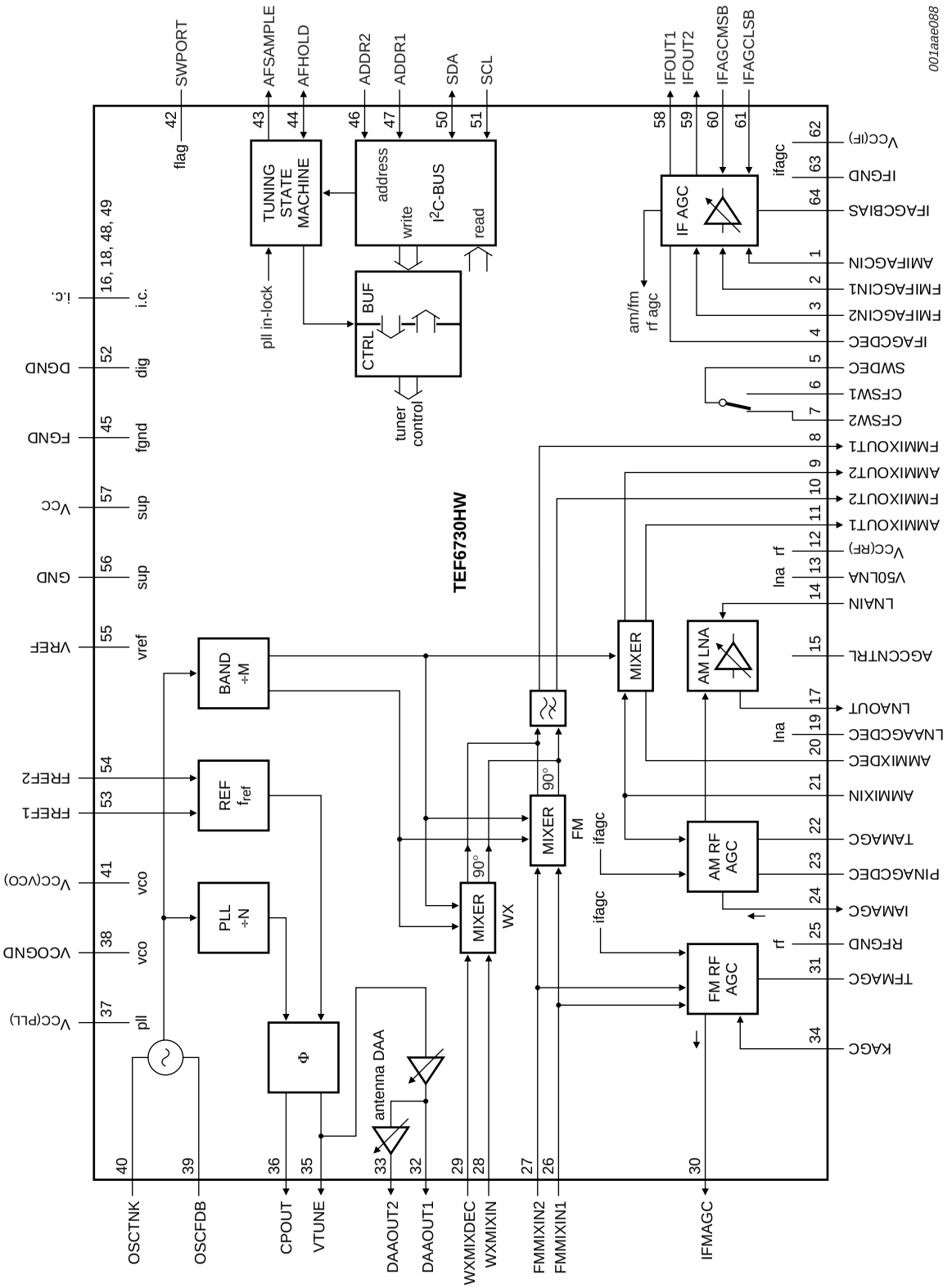



Fig 1. Block diagram of TEF6730HW


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# 6. Pinning information

## 6.1 Pinning

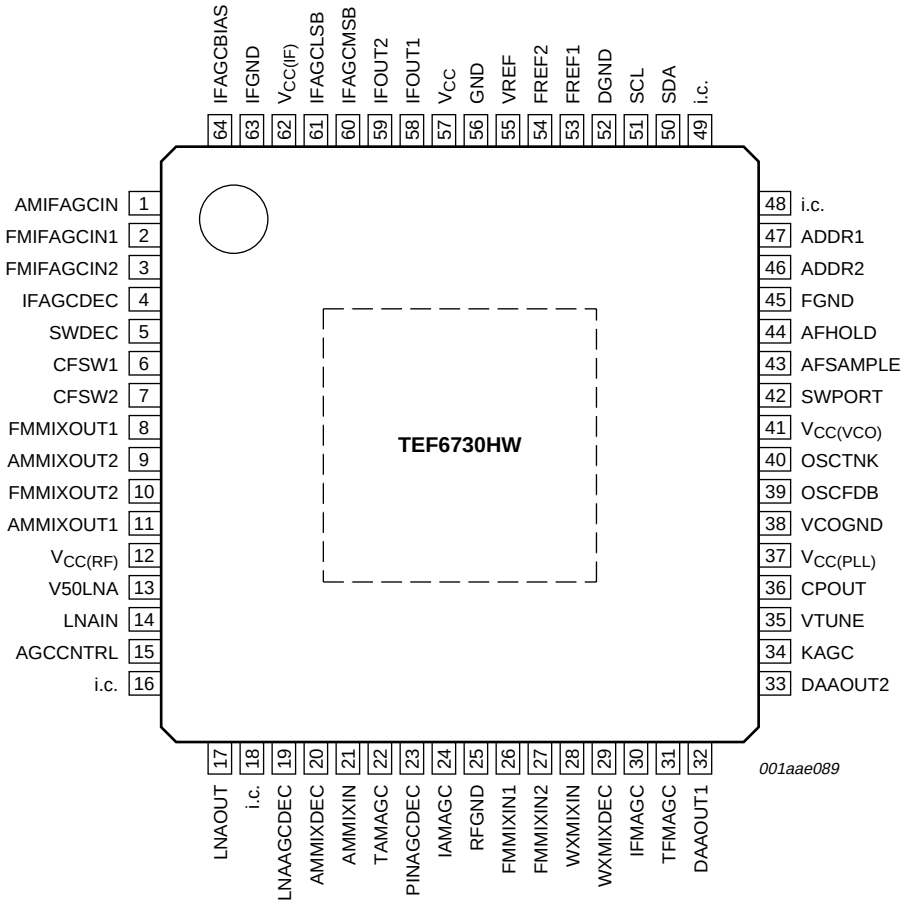



Fig 2. Pin configuration for HTQFP64

## 6.2 Pin description

Table 3. Pin description

| Symbol | Pin | Description |
|---|---|---|
| AMIFAGCIN | 1 | IF AGC amplifier AM input (10.7 MHz) |
| FMIFAGCIN1 | 2 | IF AGC amplifier FM input 1 (10.7 MHz) |
| FMIFAGCIN2 | 3 | IF AGC amplifier FM input 2 (10.7 MHz) |
| IFAGCDEC | 4 | IF AGC amplifier AM and FM decoupling |
| SWDEC | 5 | ceramic filter switch decoupling |
| CFSW1 | 6 | ceramic filter switch 1 |
| CFSW2 | 7 | ceramic filter switch 2 |
| FMMIXOUT1 | 8 | FM mixer IF output 1 (10.7 MHz) |
| AMMIXOUT2 | 9 | AM mixer IF output 2 (10.7 MHz) |


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**Table 3. Pin description** *…continued*

| Symbol | Pin | Description |
|---|---|---|
| FMMIXOUT2 | 10 | FM mixer IF output 2 (10.7 MHz) |
| AMMIXOUT1 | 11 | AM mixer IF output 1 (10.7 MHz) |
| $V_{CC(RF)}$ | 12 | AM/FM RF supply voltage |
| V50LNA | 13 | AM LNA supply voltage decoupling |
| LNAIN | 14 | AM LNA input |
| AGCCNTRL | 15 | AM LNA AGC pin |
| i.c. | 16 | internally connected; leave open |
| LNAOUT | 17 | AM LNA output |
| i.c. | 18 | internally connected; leave open |
| LNAAGCDEC | 19 | AM LNA AGC decoupling |
| AMMIXDEC | 20 | AM mixer decoupling |
| AMMIXIN | 21 | AM mixer input |
| TAMAGC | 22 | AM RF AGC time constant |
| PINAGCDEC | 23 | AM PIN diode AGC decoupling |
| IAMAGC | 24 | AGC current for AM PIN diode |
| RFGND | 25 | RF ground |
| FMMIXIN1 | 26 | FM mixer input 1 |
| FMMIXIN2 | 27 | FM mixer input 2 |
| WXMIXIN | 28 | weather band mixer input |
| WXMIXDEC | 29 | weather band mixer decoupling |
| IFMAGC | 30 | AGC current for FM PIN diode |
| TFMAGC | 31 | FM RF AGC time constant |
| DAAOUT1 | 32 | antenna DAA output 1 |
| DAAOUT2 | 33 | antenna DAA output 2 |
| KAGC | 34 | level input for FM keyed AGC function |
| VTUNE | 35 | tuning voltage input antenna DAA |
| CPOUT | 36 | charge pump output |
| $V_{CC(PLL)}$ | 37 | tuning PLL supply voltage |
| VCOGND | 38 | VCO ground |
| OSCFDB | 39 | VCO feedback |
| OSCTNK | 40 | VCO tank circuit |
| $V_{CC(VCO)}$ | 41 | VCO supply voltage |
| SWPORT | 42 | software controllable port output |
| AFSAMPLE | 43 | AF sample flag output |
| AFHOLD | 44 | AF hold flag output and input |
| FGND | 45 | reference frequency ground |
| ADDR2 | 46 | address select input 2 |
| ADDR1 | 47 | address select input 1 |
| i.c. | 48 | internally connected; leave open |
| i.c. | 49 | internally connected; leave open |
| SDA | 50 | $I^2C$-bus data line input and output |


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Table 3. Pin description *…continued*

| Symbol | Pin | Description |
|---|---|---|
| SCL | 51 | $I^2C$-bus clock line input |
| DGND | 52 | digital ground |
| FREF1 | 53 | reference frequency input 1 |
| FREF2 | 54 | reference frequency input 2 |
| VREF | 55 | reference voltage noise decoupling |
| GND | 56 | ground |
| $V_{CC}$ | 57 | supply voltage (8.5 V) |
| IFOUT1 | 58 | IF AGC amplifier output 1 |
| IFOUT2 | 59 | IF AGC amplifier output 2 |
| IFAGCMSB | 60 | MSB input for IF AGC amplifier gain setting |
| IFAGCLSB | 61 | LSB input for IF AGC amplifier gain setting |
| $V_{CC(IF)}$ | 62 | IF AGC amplifier supply voltage |
| IFGND | 63 | IF AGC amplifier ground |
| IFAGCBIAS | 64 | bias voltage decoupling for IF AGC amplifier |

# 7. Functional description

## 7.1 FM mixer 1

The FM quadrature mixer converts FM RF (65 MHz to 108 MHz) to an IF frequency of 10.7 MHz. The FM mixer provides high image rejection, a large dynamic range and selectable mixer gain. The image rejection can be selected between low injection of LO and high injection of LO via the $I^2C$-bus independently of the band selection. A separate RF input for weather band is available.

## 7.2 FM RF AGC

AGC detection at the FM front-end mixer input and the AM/FM IF AGC amplifier input, both with programmable AGC thresholds. When the threshold is exceeded, the PIN diode drive circuit sources a current to an external PIN diode circuit, keeping the RF signal level constant.

Keyed AGC function is selectable via the $I^2C$-bus and uses the in-band level information from the IF DSP.

The AGC PIN diode drive circuit can optionally deliver a fixed current as a local function. In AM mode, the AGC PIN diode drive circuit can be set to generate a fixed source current into the external FM PIN diode circuitry.

## 7.3 Antenna DAA1 and DAA2

The antenna DAA1 measures the VCO tuning voltage and multiplies it with a factor defined by the 7-bit DAA1 setting to generate a tuning voltage for the FM antenna tank circuit. If a second FM tank circuit is applied, the tuning voltage can be derived from the antenna DAA2 output. The antenna DAA2 measures the output voltage of the antenna DAA1 and multiplies it with a factor defined by the 4-bit DAA2 setting.


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### 7.4 AM LNA

The AM low noise amplifier is fully integrated.

### 7.5 AM RF AGC

The AM RF AGC is partially integrated. Detection is at the output of the AM LNA and at the input of the AM/FM IF AGC amplifier, both with programmable thresholds. First the integrated AGC reduces the gain of the LNA. After the LNA AGC, the PIN diode AGC takes over by sinking a current via an external PIN diode.

In FM mode, the AM AGC can be set to a fixed attenuation.

### 7.6 AM mixer

The large dynamic range AM mixer converts AM RF (144 kHz to 26.1 MHz) to an IF frequency of 10.7 MHz.

### 7.7 VCO and dividers

The varactor tuned LC oscillator together with the dividers provides the LO signal for both AM and FM front-end mixers. The VCO has an operating frequency of approximately 160 MHz to 256 MHz. In FM mode the LO frequency is divided by 2 or 3. These dividers generate in-phase and quadrature-phase output signals used in the FM front-end mixer for image rejection. In weather band mode the LO signal is directly phase shifted to generate the in-phase and quadrature-phase signals. In AM mode the LO frequency is divided by 6, 8, 10, 16 or 20 depending on the selected AM band.

### 7.8 Tuning PLL

The tuning PLL locks the VCO frequency divided by the programmable divider ratio to the reference frequency. Due to the combination of different charge pump signals in the PLL loop filter, the loop parameters are adapted dynamically. Tuning to different RF frequencies is done by changing the programmable divider ratio. The tuning step size is selected with the reference frequency divider setting.

### 7.9 AM/FM IF AGC amplifier

The combined AM/FM IF AGC amplifier delivers a suitable IF signal for the ADC in the IF DSP. The maximum gain of the IF AGC amplifier can be selected via the $I^2C$-bus. The gain of this amplifier is automatically adapted via interfacing signals from the IF DSP. The IF AGC amplifier has three signal inputs, two for FM and one for AM. This allows the application of multiple external filters, e.g. with different bandwidths.

## 8. $I^2C$-bus protocol

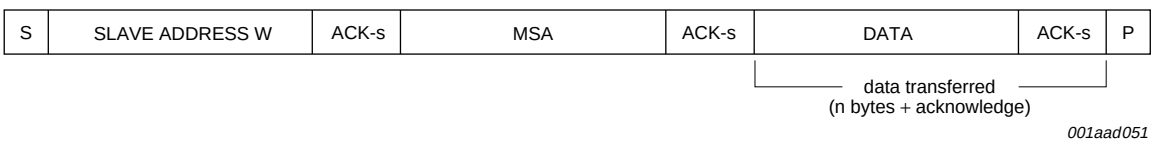



**Fig 3. Write mode**


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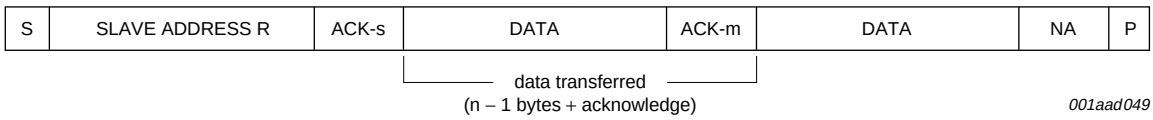



**Fig 4. Read mode**

**Table 4. Description of I²C-bus format**

| Code | Description |
|---|---|
| S | START condition |
| Slave address W | 1100 0000b for pin ADDR2 and pin ADDR1 grounded |
| | 1100 0010b for pin ADDR2 grounded and pin ADDR1 floating |
| | 1100 0100b for pin ADDR2 floating and pin ADDR1 grounded |
| | 1100 0110b for pin ADDR2 and pin ADDR1 floating |
| Slave address R | 1100 0001b for pin ADDR2 and pin ADDR1 grounded |
| | 1100 0011b for pin ADDR2 grounded and pin ADDR1 floating |
| | 1100 0101b for pin ADDR2 floating and pin ADDR1 grounded |
| | 1100 0111b for pin ADDR2 and pin ADDR1 floating |
| ACK-s | acknowledge generated by the slave |
| ACK-m | acknowledge generated by the master |
| NA | not acknowledge |
| MSA | mode and subaddress byte |
| Data | data byte |
| P | STOP condition |

## 8.1 Read mode

Read data is loaded into the I²C-bus register at the preceding acknowledge clock pulse.

**Table 5. Read register overview**

| Data byte | Name | Reference |
|---|---|---|
| 0h | TUNER | Section 8.1.1 |
| 1h | ID | Section 8.1.2 |

### 8.1.1 Read mode: data byte TUNER

**Table 6. TUNER - data byte 0h bit allocation**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| RAGC1 | RAGC0 | TAS1 | TAS0 | - | - | - | POR |


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Table 7. TUNER - data byte 0h bit description

| Bit | Symbol | Description |
|---|---|---|
| 7 and 6 | RAGC[1:0] | RF AGC attenuation indicator, PIN diode current on pin IFMAGC |
| | | AM mode: |
| | | 00 = no AGC |
| | | 01 = LNA AGC |
| | | 10 = $I_{AGC}$ < 1 mA |
| | | 11 = $I_{AGC}$ > 1 mA |
| | | FM mode: |
| | | 00 = < 0.1 mA |
| | | 01 = 0.1 mA to 0.5 mA |
| | | 10 = 0.5 mA to 2.5 mA |
| | | 11 = > 2.5 mA |
| 5 and 4 | TAS[1:0] | tuning action state; the signal TAS informs about internal control functions of the tuner action state machine; this way the progress of tuner actions can be monitored by the microcontroller; see Figure 8 to Figure 18 |
| | | 00 = no current action |
| | | 01 = mute started and in progress at DSP |
| | | 10 = PLL tuning in progress and mute activated at DSP |
| | | 11 = PLL tuning ready and mute activated at DSP |
| 3 to 1 | - | not used |
| 0 | POR | power-on reset |
| | | 0 = normal operation |
| | | 1 = $I^2C$-bus data is reset to default POR state; POR is reset to logic 0 after the TEF6730 has been read out and written to via $I^2C$-bus at least once |

### 8.1.2 Read mode: data byte ID

Table 8. ID - data byte 1h bit allocation

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| - | - | - | - | - | ID2 | ID1 | ID0 |

Table 9. ID - data byte 1h bit description

| Bit | Symbol | Description |
|---|---|---|
| 7 to 3 | - | not used |
| 2 to 0 | ID[2:0] | device type identification 110 = TEF6730 |

## 8.2 Write mode

The tuner is controlled by the $I^2C$-bus. After the IC address the MSA byte contains the control of the tuning action via the bits MODE[2:0] and REGC and subaddressing via bits SA[3:0] (see Figure 5).


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The tuner circuit is controlled by the CONTROL register. Any data change in the CONTROL register has immediate effect and will change the operation of the tuner circuit accordingly. Transmitted $I^2C$-bus data is not loaded into the CONTROL register directly but loaded into a BUFFER register instead. This allows the IC to take care of tuning actions freeing the microcontroller from cumbersome controls and timings.

Controlled by a state machine, the BUFFER data will be loaded into the CONTROL register for new settings. However, at the same time the CONTROL data is loaded into the BUFFER register. This register swap action allows a fast return to the previous setting because the previous data remains available in the BUFFER register (see Figure 6 and Figure 7).

Via MODE several operational modes can be selected for the state machine. MODE offers all standard tuning actions as well as generic control for flexibility. The state machine controls the tuner by controlling the internal $I^2C$-bus data. Action progress is monitored by the accompanying IF DSP via the AFSAMPLE and AFHOLD lines. This way, functions like tuning mute and weak signal processing can be controlled complementary to the tuner action.

The state machine operation starts at the end of transmission (P = STOP). In case a previous action is still active, this is ignored and the new action defined by MODE is started immediately. When only the address byte is transmitted, no action is started at all (device presence test).

To minimize the $I^2C$-bus transmission time, only bytes that include data changes need to be written. Following the MSA byte the transmission can start at any given data byte defined by the subaddress (SA) bits.

Furthermore, when writing the buffered range either the current BUFFER data or the current CONTROL data can be used as default, controlled by the REGC bit:

- With REGC = 0, any BUFFER data that is not newly written via $I^2C$-bus remains unchanged. In general, the BUFFER register will contain the previous tuner setting, so this becomes default for the new setting. When only the MSA byte is transmitted defining a tuning MODE with REGC = 0, the tuner will return to its previous settings (see Figure 6).
- With REGC = 1, the BUFFER register is loaded with data from the CONTROL register first. This way, not written BUFFER data equals the CONTROL data. Since the CONTROL register contains the current tuner setting with REGC = 1, the current tuner setting is default for the new setting. When a tuning MODE action is defined with REGC = 1, the tuner will keep its current settings (CONTROL = current) for all data that is not newly written during the transmission (see Figure 7).

After power-on reset, all registers are in their default settings. The control signals for the IF DSP are set to AFSAMPLE = HIGH and AFHOLD = HIGH (i.e. mute state). Any action of the state machine will change this setting to a new one as defined by the bits MODE[2:0].


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**Table 10. Write mode subaddress overview**

| Subaddress | Name | Default | Reference |
|---|---|---|---|
| 0h | CONTROL | 0000 0100b | Section 8.2.2 |
| 1h | PLLM | 0000 1000b | Section 8.2.3 |
| 2h | PLLL | 0111 1110b | Section 8.2.4 |
| 3h | DAA | 0100 0000b | Section 8.2.5 |
| 4h | AGC | 1000 0000b | Section 8.2.6 |
| 5h | BAND | 0010 0000b | Section 8.2.7 |
| Fh | TEST | 0000 0000b | Section 8.2.8 |

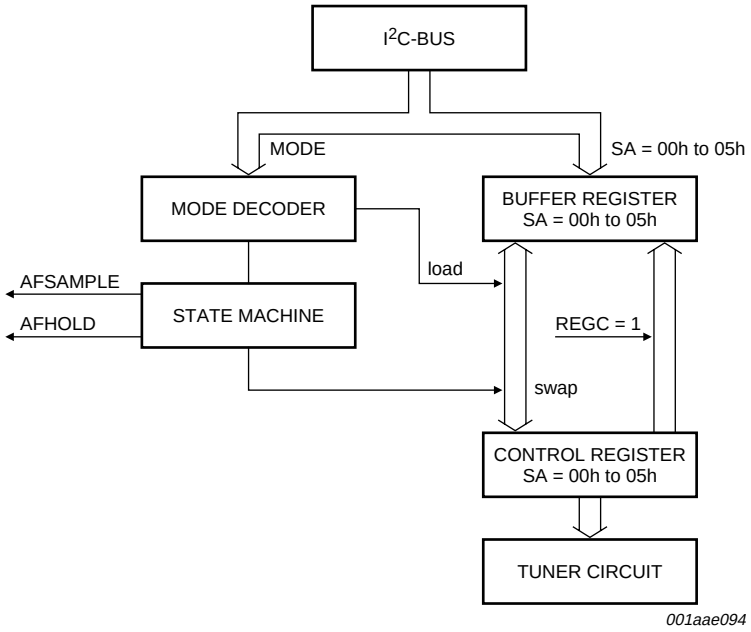



**Fig 5. I²C-bus control**


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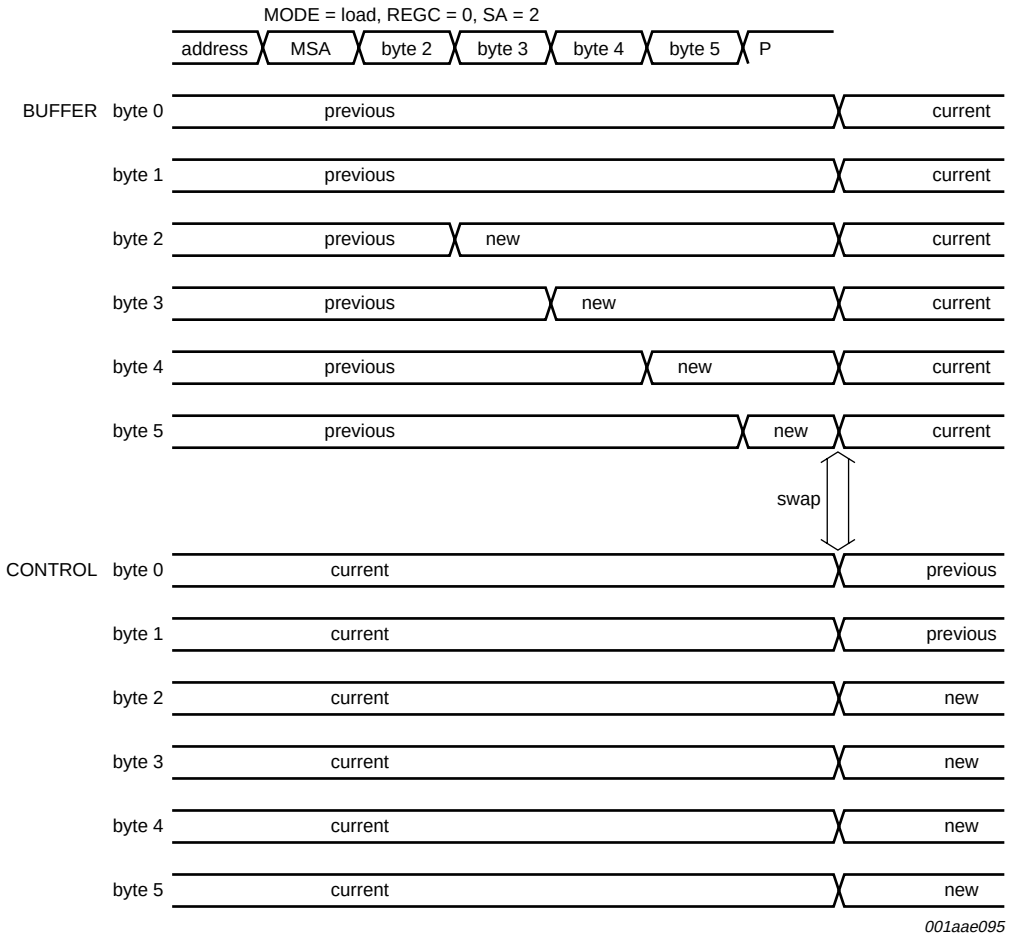



**Fig 6. Write to CONTROL register with swap, REGC = 0**



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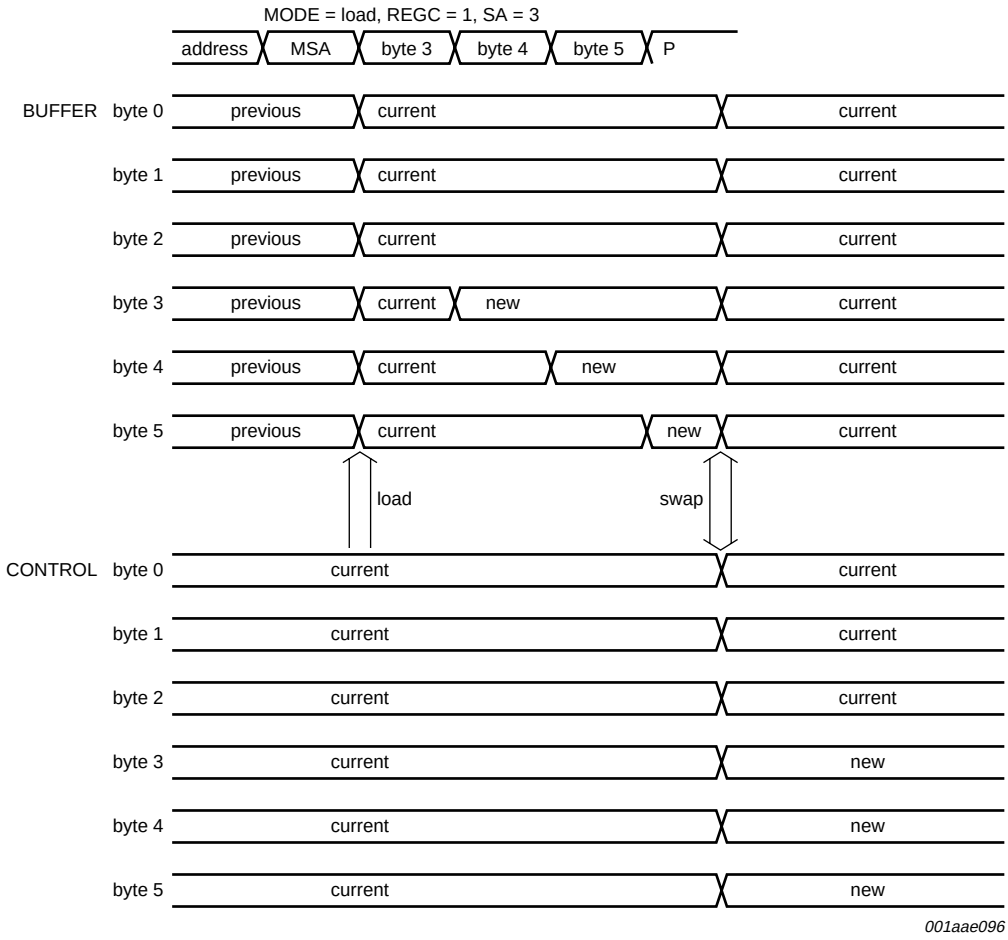



**Fig 7. Write to CONTROL register with swap, REGC = 1**



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### 8.2.1 Mode and subaddress byte for write

**Table 11. MSA - mode and subaddress byte bit allocation**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| MODE2 | MODE1 | MODE0 | REGC | SA3 | SA2 | SA1 | SA0 |

**Table 12. MSA - mode and subaddress byte bit description**

| Bit | Symbol | Description |
|---|---|---|
| 7 to 5 | MODE[2:0] | mode; see Table 13 |
| 4 | REGC | register mode |
| | | 0 = buffer mode or back mode: previous tuning data is default for new I²C-bus write (data of the BUFFER register is not changed before I²C-bus write); see Figure 6 |
| | | 1 = control mode or current mode: current tuning data is default for new I²C-bus write (the BUFFER register is loaded with CONTROL register data before I²C-bus write); see Figure 7 |
| 3 to 0 | SA[3:0] | subaddress; write data byte subaddress 0 to 15. The subaddress value is auto-incremented and will revert from SA = 15 to SA = 0. The auto-increment function cannot be switched off. |

**Table 13. Tuning action modes[1]**

| MODE2 | MODE1 | MODE0 | Symbol | Description[2] |
|---|---|---|---|---|
| 0 | 0 | 0 | buffer | write BUFFER register, no state machine action, no swap |
| 0 | 0 | 1 | preset | tune to new program with 60 ms mute control; swap[3]; see Figure 8 and Figure 9 |
| 0 | 1 | 0 | search | tune to new program and stay muted (for release use end mode); swap[3]; see Figure 10 and Figure 11 |
| 0 | 1 | 1 | AF update | tune to AF program; check AF quality and tune back to main program; two swap operations[4]; see Figure 12 and Figure 13 |
| 1 | 0 | 0 | jump | tune to AF program in minimum time; swap; see Figure 14 and Figure 15 |
| 1 | 0 | 1 | check | tune to AF program and stay muted (for release use end mode); swap; see Figure 16 and Figure 17 |
| 1 | 1 | 0 | load | write CONTROL register via BUFFER; no state machine action; immediate swap; see Figure 6 and Figure 7 |
| 1 | 1 | 1 | end | end action; release mute; no swap; see Figure 18 |

[1] When the write transmission of a state machine command starts during a mute state of the state machine, the sequences of the state machine start immediately with the actions which follow the mute period in the standard sequence (see Figure 9, Figure 11, Figure 13, Figure 15 and Figure 17).

[2] References to mute are only used for better understanding. Muting is performed in the IF DSP controlled by the tuner AFHOLD and AFSAMPLE lines.

[3] In the modes preset and search the AM AGC time constant is set to fast during the period of complete mute.

[4] The AF update sequence can also be started by pulling the AFHOLD pin LOW. In this case the AF information should be loaded into the BUFFER before. LOW period for a correct AF update timing: $t_{LOW} > 20$ µs. Between the end of the I²C-bus transmission and the falling edge of the AFHOLD pulse a delay of ≥ 20 µs is necessary.


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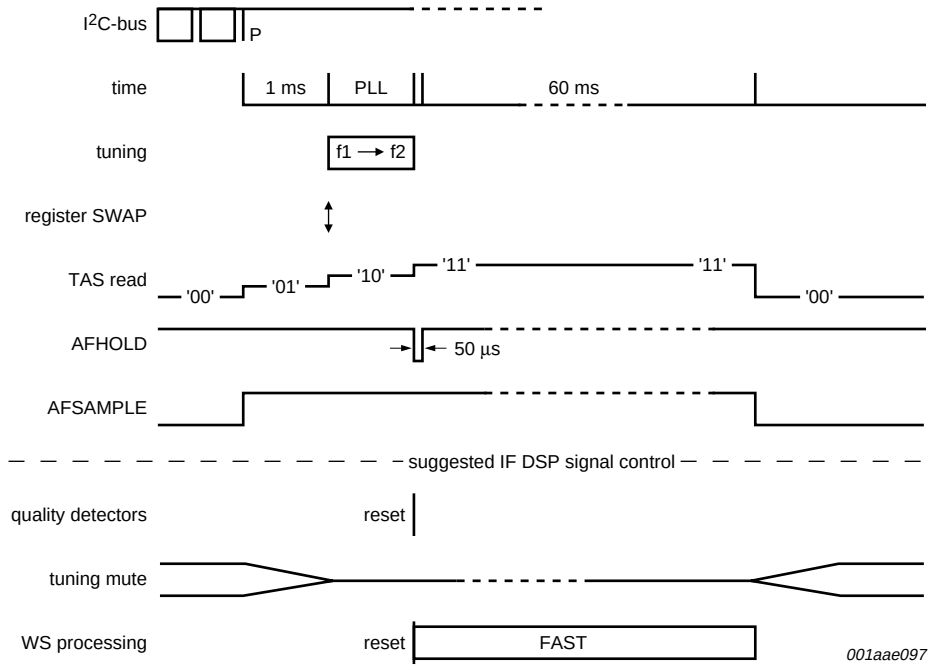



**Fig 8. Preset mode**

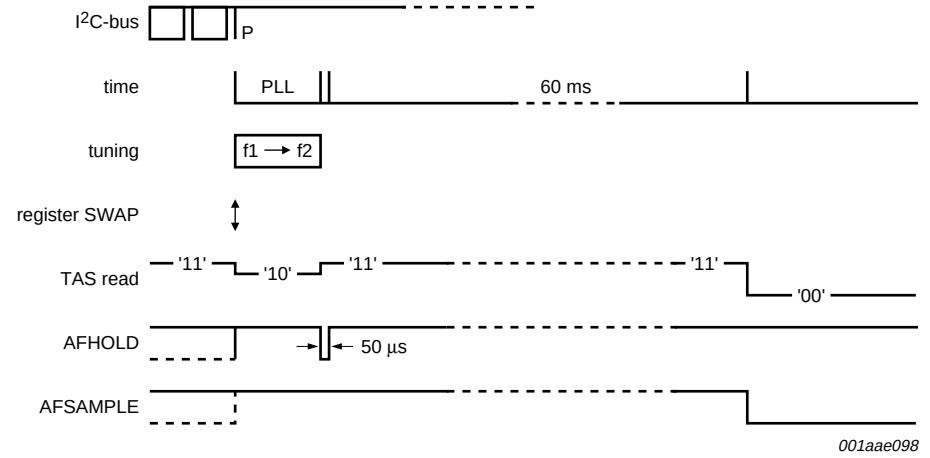



**Fig 9. Preset mode, started during mute**


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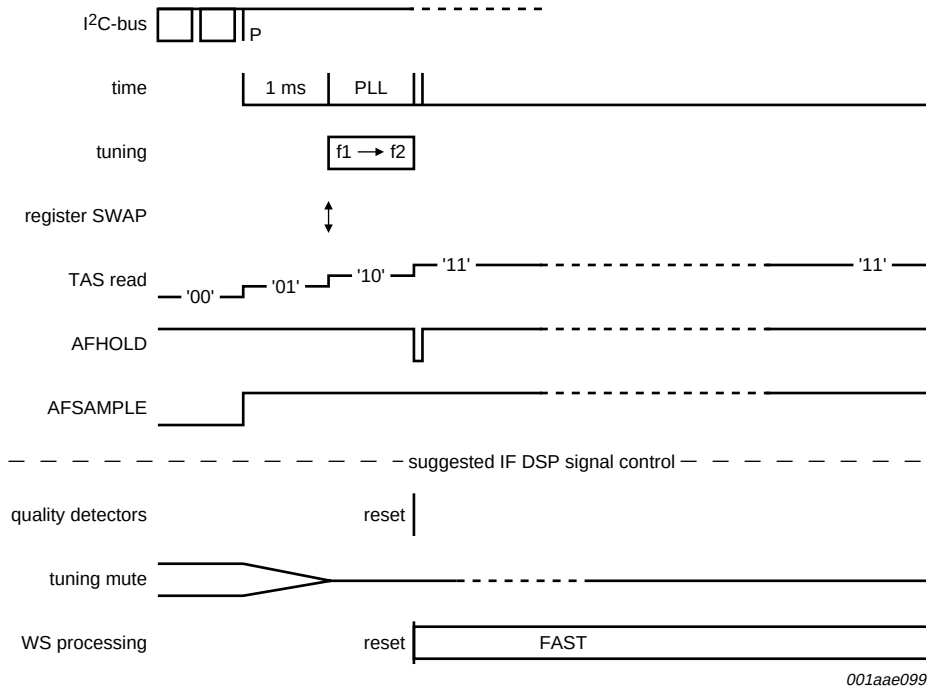



**Fig 10. Search mode**

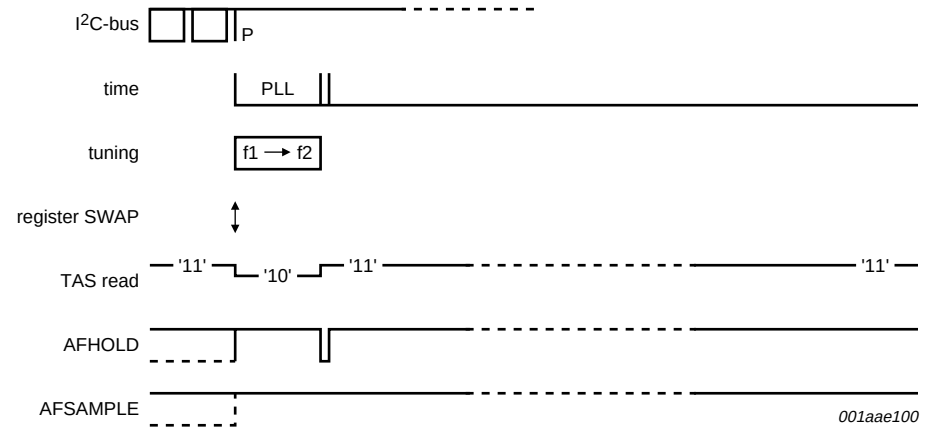



**Fig 11. Search mode, started during mute**



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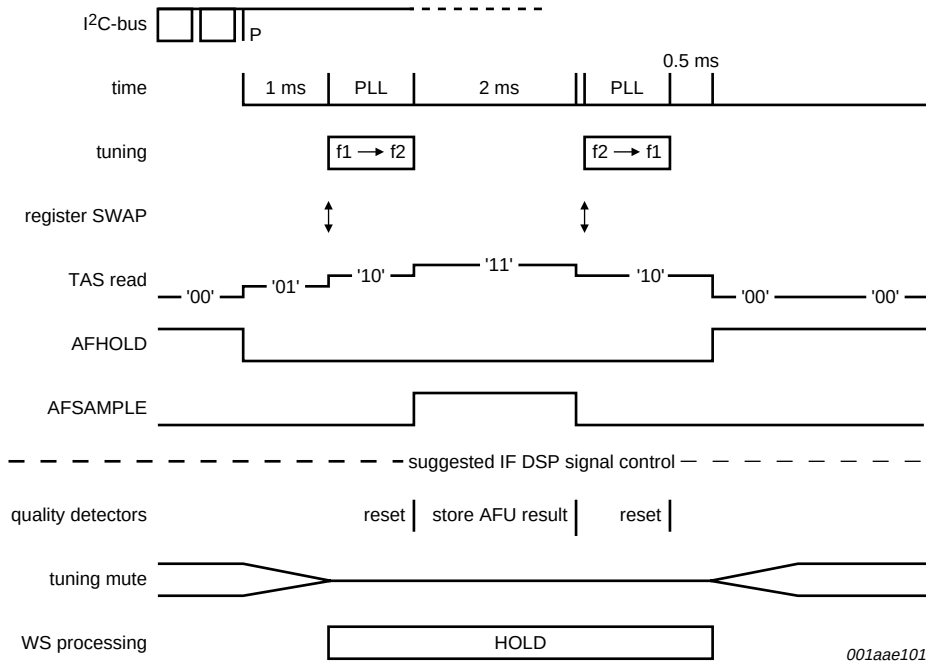



**Fig 12. AF update mode**

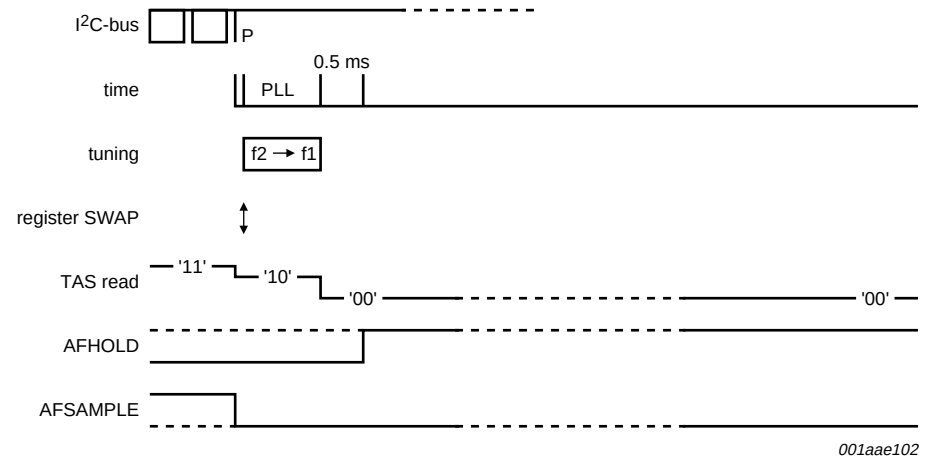



**Fig 13. AF update mode, started during mute**


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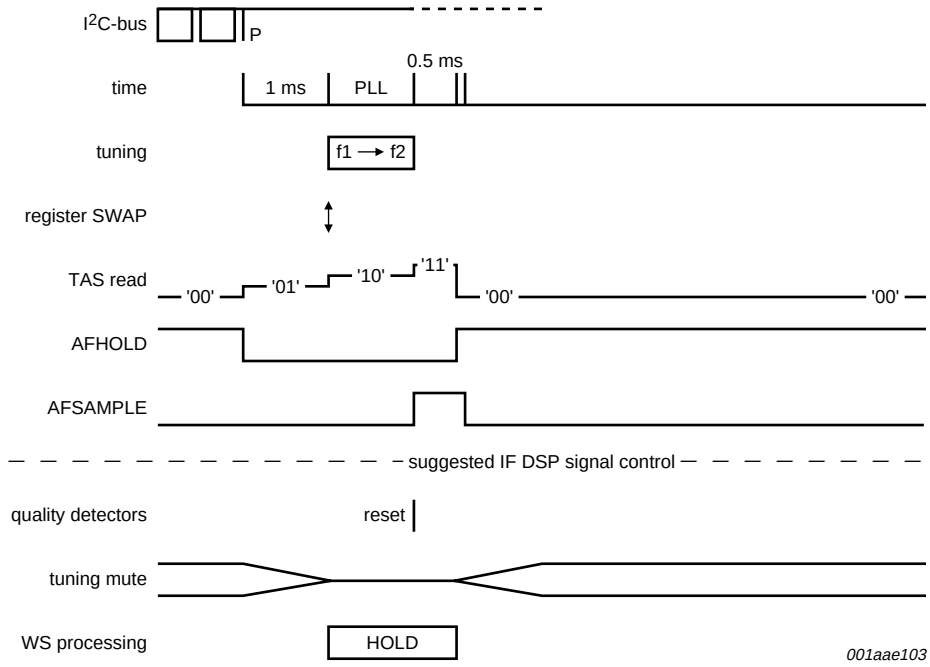



**Fig 14. Jump mode**

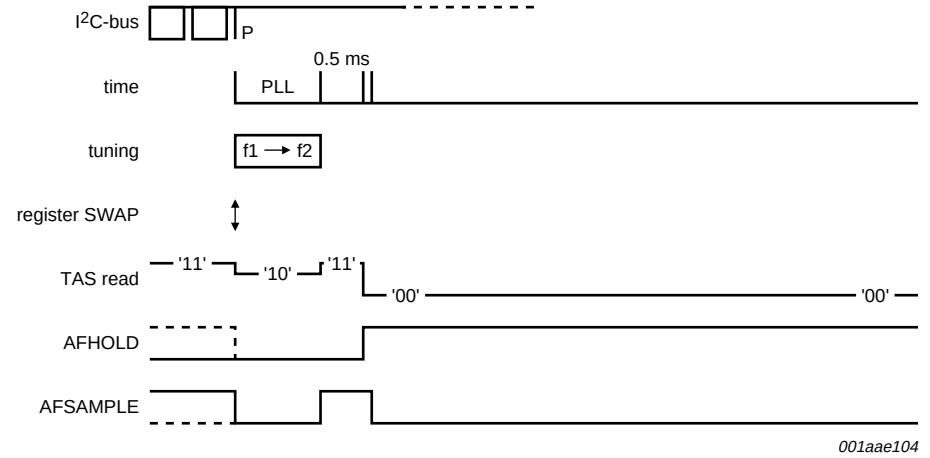



**Fig 15. Jump mode, started during mute**



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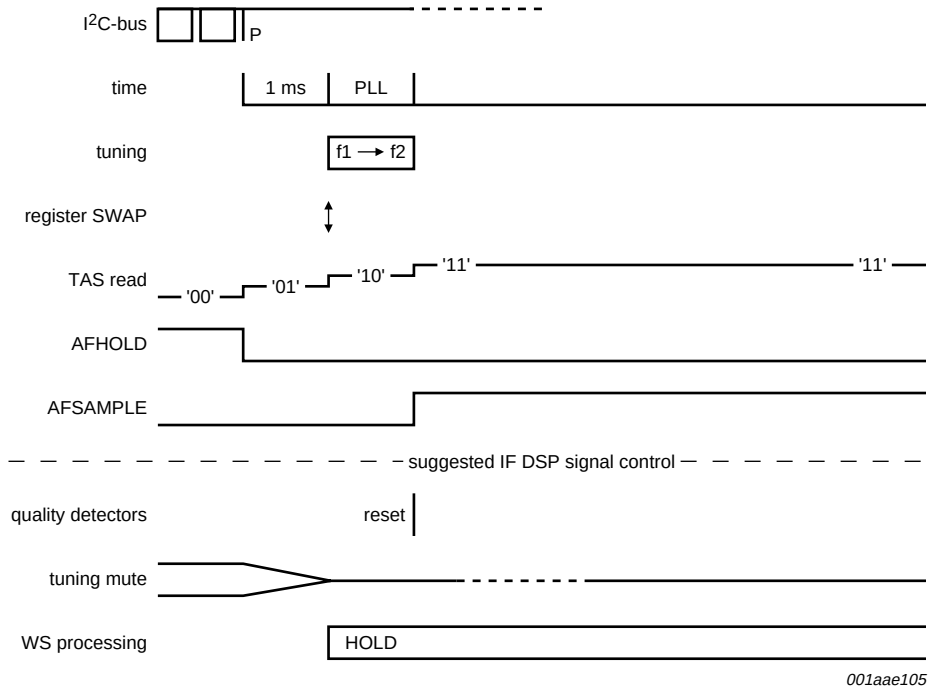



**Fig 16. Check mode**

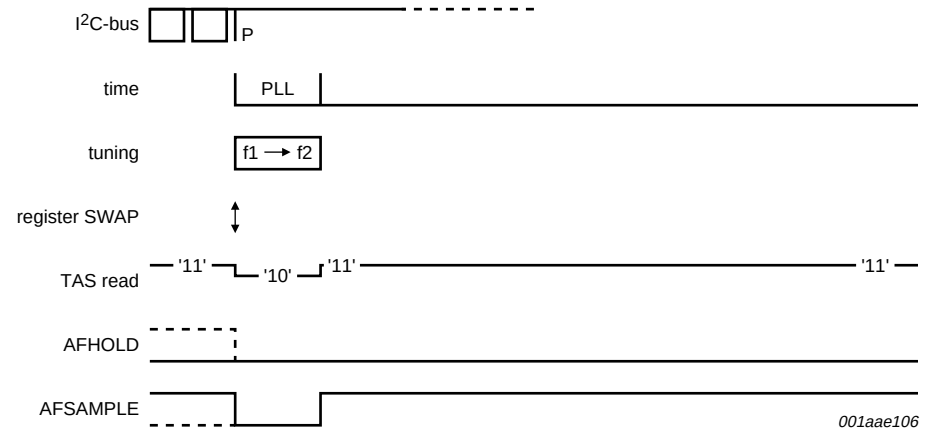



**Fig 17. Check mode, started during mute**



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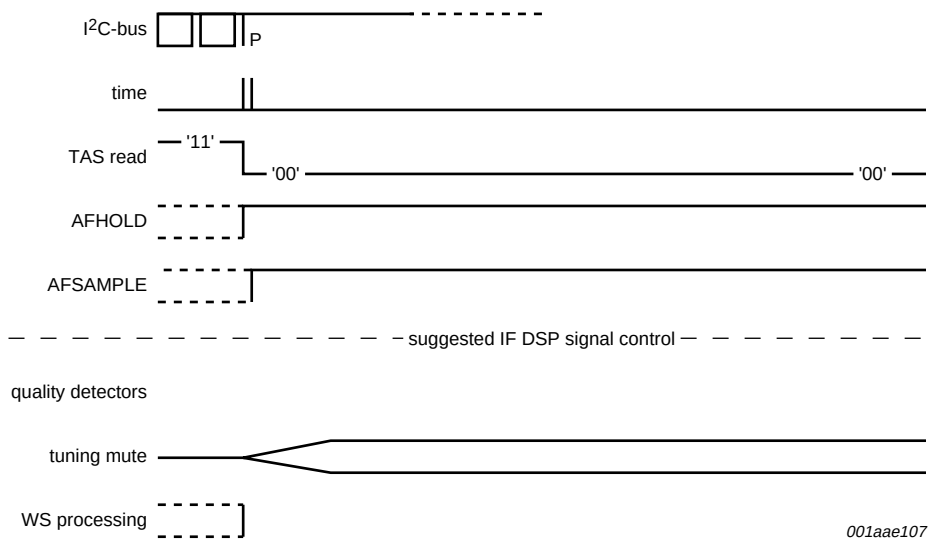



Fig 18. End mode

### 8.2.2 Write mode: data byte CONTROL

Table 14. CONTROL - data byte 0h bit allocation with default setting

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| RFGAIN | 0 | FLAG | IFGAIN | NBAGC1 | NBAGC0 | DAASW | CFSW |
| 0 | | 0 | 0 | 0 | 1 | 0 | 0 |

Table 15. CONTROL - data byte 0h bit description

| Bit | Symbol | Description |
|---|---|---|
| 7 | RFGAIN | FM RF gain |
| | | 0 = standard gain |
| | | 1 = +6 dB added gain |
| 6 | - | not used, must be set to logic 0 |
| 5 | FLAG | software port output open-collector |
| | | 0 = SWPORT pin inactive (high-impedance) |
| | | 1 = SWPORT pin active (pull-down to ground) |
| 4 | IFGAIN | IF gain |
| | | 0 = standard IF gain |
| | | 1 = increased IF gain (6 dB) |
| 3 and 2 | NBAGC[1:0] | RF AGC start level; setting of narrow band (IF) detection |
| | | 00 = 700 mV (peak value) |
| | | 01 = 560 mV (peak value) |
| | | 10 = 450 mV (peak value) |
| | | 11 = 350 mV (peak value) |


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Table 15. CONTROL - data byte 0h bit description *...continued*

| Bit | Symbol | Description |
|---|---|---|
| 1 | DAASW | antenna DAA mode in FM |
| | | 0 = standard; DAA output voltage is controlled by $V_{tune}$ |
| | | 1 = DAA output voltage is a fixed temperature stable voltage controlled by the DAA setting (independent of $V_{tune}$) |
| 0 | CFSW | ceramic filter switch |
| | | 0 = CFSW1 pin active (low-impedance) and CFSW2 pin inactive (high-impedance) |
| | | 1 = CFSW2 pin active (low-impedance) and CFSW1 pin inactive (high-impedance) |

### 8.2.3 Write mode: data byte PLLM

Table 16. PLLM - data byte 1h bit allocation with default setting

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| CPOFF | PLL14 | PLL13 | PLL12 | PLL11 | PLL10 | PLL9 | PLL8 |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

Table 17. PLLM - data byte 1h bit description

| Bit | Symbol | Description |
|---|---|---|
| 7 | CPOFF | charge pump off |
| | | 0 = standard operation |
| | | 1 = charge pump deactivated |
| 6 to 0 | PLL[14:8] | upper byte of PLL divider word |

### 8.2.4 Write mode: data byte PLLL

Table 18. PLLL - data byte 2h bit allocation with default setting

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| PLL7 | PLL6 | PLL5 | PLL4 | PLL3 | PLL2 | PLL1 | PLL0 |
| 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |

Table 19. PLLL - data byte 2h bit description

| Bit | Symbol | Description |
|---|---|---|
| 7 to 0 | PLL[7:0] | lower byte of PLL divider word; PLL[14:0] is the divider ratio N of the VCO programmable divider; N = 1024 to 32767 |

### 8.2.5 Write mode: data byte DAA

Table 20. DAA - data byte 3h bit allocation with default setting

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| AGCSW | DAA6 | DAA5 | DAA4 | DAA3 | DAA2 | DAA1 | DAA0 |
| 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |


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**Table 21. DAA - data byte 3h bit description**

| Bit | Symbol | Description |
|---|---|---|
| 7 | AGCSW | RF AGC switch |
| | | 0 = no drive of unused RF AGC PIN diode (FM PIN diode in AM mode or AM PIN diode in FM mode) |
| | | 1 = unused PIN diode supplied with constant current |
| 6 to 0 | DAA[6:0] | alignment of antenna circuit tuning voltage in FM mode ($0.1V_{tune}$ to $2.0V_{tune}$) |

### 8.2.6 Write mode: data byte AGC

**Table 22. AGC - data byte 4h bit allocation with default setting**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| SDAA3 | SDAA2 | SDAA1 | SDAA0 | WBAGC1 | WBAGC0 | KAGC | LODX |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

**Table 23. AGC - data byte 4h bit description**

| Bit | Symbol | Description |
|---|---|---|
| 7 to 4 | SDAA[3:0] | alignment of second antenna circuit tuning voltage in FM mode ($0.7V_{DAAOUT1}$ to $1.35V_{DAAOUT1}$) |
| 3 and 2 | WBAGC[1:0] | RF AGC start level; setting of wideband (RF) detection; for AM, see Table 24 and for FM, see Table 25 |
| 1 | KAGC | FM keyed AGC |
| | | 0 = keyed AGC off |
| | | 1 = keyed AGC on |
| 0 | LODX | local switch |
| | | 0 = standard operation (DX) |
| | | 1 = forced FM RF AGC attenuation (LOCAL) |

**Table 24. Setting of RF AGC threshold voltage for AM**

| WBAGC1 | WBAGC0 | AM output (RMS value) at LNAOUT |
|---|---|---|
| 0 | 0 | 250 mV |
| 0 | 1 | 200 mV |
| 1 | 0 | 150 mV |
| 1 | 1 | 70 mV |

**Table 25. Setting of RF AGC threshold voltage for FM**

| WBAGC1 | WBAGC0 | FM mixer input voltage (RMS value) at FMMIXIN |
|---|---|---|
| 0 | 0 | 24 mV |
| 0 | 1 | 17 mV |
| 1 | 0 | 12 mV |
| 1 | 1 | 9 mV |


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### 8.2.7 Write mode: data byte BAND

Table 26. BAND - data byte 5h bit allocation with default setting

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| BAND2 | BAND1 | BAND0 | FREF2 | FREF1 | FREF0 | LOINJ | FMIFIN |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |

Table 27. BAND - data byte 5h bit description

| Bit | Symbol | Description |
|---|---|---|
| 7 to 5 | BAND[2:0] | see Table 28 |
| 4 to 2 | FREF[2:0] | PLL reference frequency; see Table 29 |
| 1 | LOINJ | 0 = high injection image suppression |
| | | 1 = low injection image suppression |
| 0 | FMIFIN | 0 = FMIFAGCIN1 input is selected |
| | | 1 = FMIFAGCIN2 input is selected |

Table 28. Decoding of BAND bits

| BAND2 | BAND1 | BAND0 | Divider ratio M | Receiver band |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | WB |
| 0 | 0 | 1 | 2 | FM |
| 0 | 1 | 0 | 3 | FM |
| 0 | 1 | 1 | 6 | AM |
| 1 | 0 | 0 | 8 | AM |
| 1 | 0 | 1 | 10 | AM |
| 1 | 1 | 0 | 16 | AM |
| 1 | 1 | 1 | 20 | AM |

Table 29. Reference frequencies

| FREF2 | FREF1 | FREF0 | $f_{ref}$ |
|---|---|---|---|
| 0 | 0 | 0 | 100 kHz |
| 0 | 0 | 1 | 50 kHz |
| 0 | 1 | 0 | 25 kHz |
| 0 | 1 | 1 | 20 kHz |
| 1 | 0 | 0 | 10 kHz |
| 1 | 0 | 1 | reserved |
| 1 | 1 | 0 | reserved |
| 1 | 1 | 1 | reserved |

The correct charge pump current for each reference frequency is selected automatically, see Table 30.


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**Table 30. Charge pump source[1]**

| FREF2 | FREF1 | FREF0 | LOINJ | Charge pump current | $f_{ref}$ |
|---|---|---|---|---|---|
| 0 | 0 | 0 | X | CP1 | 100 kHz |
| 0 | 0 | 1 | X | CP2 | 50 kHz |
| 0 | 1 | 0 | X | CP3 | 25 kHz |
| 0 | 1 | 1 | 1 | CP3 | 20 kHz |
| 0 | 1 | 1 | 0 | CP4 | 20 kHz |
| 1 | 0 | 0 | X | CP5 | 10 kHz |

[1] X = don't care.

#### 8.2.7.1 Tuning overview

If LOINJ = 0: $N = \frac{(f_{RF} + 10.7\ MHz) \times M}{f_{ref}}$.

If LOINJ = 1: $N = \frac{(f_{RF} - 10.7\ MHz) \times M}{f_{ref}}$.

$tuning\ step = \frac{f_{ref}}{M}$; where M is the divider ratio of the VCO frequency for AM mixer and FM mixer $M = \frac{f_{VCO}}{f_{mixer}}$.

**Table 31. Standard tuner settings**

| Broadcast band | BAND2 | BAND1 | BAND0 | M | FREF2 | FREF1 | FREF0 | $f_{ref}$ | LOINJ | Tuning step |
|---|---|---|---|---|---|---|---|---|---|---|
| Europe FM and US FM | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 100 kHz | 0 | 50 kHz |
| Japan FM | 0 | 1 | 0 | 3 | 0 | 0 | 0 | 100 kHz | 1 | 33.3 kHz |
| East Europe FM (OIRT FM) | 0 | 1 | 0 | 3 | 0 | 1 | 1 | 20 kHz | 1 | 6.67 kHz |
| WB FM | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 25 kHz | 0 | 25 kHz |
| AM MW and LW | 1 | 1 | 1 | 20 | 0 | 1 | 1 | 20 kHz | 0 | 1 kHz |
| AM SW 120 m to 60 m | 1 | 1 | 0 | 16 | 1 | 0 | 0 | 10 kHz | 0 | 0.625 kHz |
| AM SW 49 m to 22 m | 1 | 0 | 1 | 10 | 1 | 0 | 0 | 10 kHz | 0 | 1 kHz |
| AM SW 25 m to 15 m | 1 | 0 | 0 | 8 | 1 | 0 | 0 | 10 kHz | 0 | 1.25 kHz |
| AM SW 16 m to 11 m | 0 | 1 | 1 | 6 | 1 | 0 | 0 | 10 kHz | 0 | 1.67 kHz |

### 8.2.8 Write mode: data byte TEST

**Table 32. TEST - data byte Fh bit allocation with default setting (not buffered)[1]**

| 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | TEST3 | TEST2 | TEST1 | TEST0 |
| | | | | 0 | 0 | 0 | 0 |

[1] The test control byte is for internal use only.


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# 9. Limiting values

**Table 33. Limiting values**

*In accordance with the Absolute Maximum Rating System (IEC 60134).*

| Symbol | Parameter | Conditions | | Min | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{CCA}$ | analog supply voltage | on pins $V_{CC}$, $V_{CC(PLL)}$, $V_{CC(VCO)}$, $V_{CC(RF)}$, $V_{CC(IF)}$, FMMIXOUT1, FMMIXOUT2, AMMIXOUT1 and AMMIXOUT2 | | −0.3 | +10 | V |
| $\Delta V_{CCAn}$ | voltage difference between any analog supply pins | | | −0.3 | +0.3 | V |
| $V_{SCL}$ | voltage on pin SCL | | | −0.3 | +5.5 | V |
| $V_{SDA}$ | voltage on pin SDA | | | −0.3 | +5.5 | V |
| $V_i$ | input voltage | on pins ADDR1 and ADDR2 | [1] | −0.3 | +5.5 | V |
| $V_o$ | output voltage | on pins AFHOLD and AFSAMPLE | | −0.3 | +5.5 | V |
| | | on pin SWPORT | | −0.3 | +10 | V |
| $V_n$ | voltage on any other pin | | | −0.3 | $V_{CCA}$ + 0.3 | V |
| $P_{tot}$ | total power dissipation | | | - | 1100 | mW |
| $T_{stg}$ | storage temperature | | | −55 | +150 | °C |
| $T_{amb}$ | ambient temperature | soldered exposed die pad | | | | |
| | | subjective functionality | | −40 | +105 | °C |
| | | full functionality | | −40 | +85 | °C |
| $V_{esd}$ | electrostatic discharge voltage | on all pins except pin $V_{CC(VCO)}$ | [2] | −2000 | +2000 | V |
| | | | [3] | −200 | +200 | V |
| | | on pin $V_{CC(VCO)}$ | [4] | −1000 | +2000 | V |
| | | | [3] | −200 | +200 | V |

[1] The maximum voltage must be less than $V_{CCA}$.

[2] Human body model: Class 2 according to JESD22-A114C.01.

[3] Machine model: Class B according to EIA/JESD22-A115-A.

[4] Human body model: Class 1C according to JESD22-A114C.01.

# 10. Thermal characteristics

**Table 34. Thermal characteristics**

| Symbol | Parameter | Conditions | Typ | Unit |
|---|---|---|---|---|
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | in free air | 29.6 | K/W |
| $R_{th(j-c)}$ | thermal resistance from junction to case | | 17.5 | K/W |



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# 11. Static characteristics

**Table 35. Static characteristics**

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Supply voltage** | | | | | | |
| $V_{CCA}$ | analog supply voltage | on pins $V_{CC}$, $V_{CC(PLL)}$, $V_{CC(VCO)}$, $V_{CC(RF)}$, $V_{CC(IF)}$, FMMIXOUT1, FMMIXOUT2, AMMIXOUT1 and AMMIXOUT2 | 8 | 8.5 | 9 | V |
| **Current in FM mode** | | | | | | |
| $I_{CC(RF)}$ | RF supply current | $T_{amb}$ = –40 °C | - | 14 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 15 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 16 | - | mA |
| $I_{CC(PLL)}$ | PLL supply current | $T_{amb}$ = –40 °C | - | 7.9 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 7.6 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 7.2 | - | mA |
| $I_{CC(VCO)}$ | VCO supply current | $T_{amb}$ = –40 °C | - | 3.8 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 3.6 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 3.5 | - | mA |
| $I_{CC}$ | supply current | $T_{amb}$ = –40 °C | - | 23 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 21.5 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 19 | - | mA |
| $I_{CC(IFAGC)}$ | IF AGC supply current | $T_{amb}$ = –40 °C | - | 26 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 26 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 26 | - | mA |
| $I_{FMMIXOUT1}$ | current on pin FMMIXOUT1 | $T_{amb}$ = –40 °C | - | 5.3 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 5.8 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 6.1 | - | mA |
| $I_{FMMIXOUT2}$ | current on pin FMMIXOUT2 | $T_{amb}$ = –40 °C | - | 5.3 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 5.8 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 6.1 | - | mA |
| $I_{CC(tot)}$ | total supply current | | - | 85.3 | - | mA |
| **Current in AM mode** | | | | | | |
| $I_{CC(RF)}$ | RF supply current | $T_{amb}$ = –40 °C | - | 39.5 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 39 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 38 | - | mA |
| $I_{CC(PLL)}$ | PLL supply current | $T_{amb}$ = –40 °C | - | 7.9 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 7.6 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 7.2 | - | mA |
| $I_{CC(VCO)}$ | VCO supply current | $T_{amb}$ = –40 °C | - | 3.8 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 3.6 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 3.5 | - | mA |


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**Table 35. Static characteristics** *...continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{CC}$ | supply current | $T_{amb}$ = –40 °C | - | 21.5 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 21 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 20 | - | mA |
| $I_{CC(IFAGC)}$ | IF AGC supply current | $T_{amb}$ = –40 °C | - | 33 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 32.5 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 32 | - | mA |
| $I_{AMMIXOUT1}$ | current on pin AMMIXOUT1 | $T_{amb}$ = –40 °C | - | 6 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 5.5 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 5 | - | mA |
| $I_{AMMIXOUT2}$ | current on pin AMMIXOUT2 | $T_{amb}$ = –40 °C | - | 6 | - | mA |
| | | $T_{amb}$ = 25 °C | - | 5.5 | - | mA |
| | | $T_{amb}$ = 85 °C | - | 5 | - | mA |
| $I_{CC(tot)}$ | total supply current | | - | 114.7 | - | mA |

# 12. Dynamic characteristics

**Table 36. Dynamic characteristics**

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| **Reference frequency** | | | | | | | |
| External reference frequency, circuit inputs: pins FREF1 and FREF2 | | | | | | | |
| $f_{ext}$ | external frequency | | | - | 100 | - | kHz |
| C/N | carrier-to-noise ratio | required from reference source; $f_{ext}$ = 100 kHz; $\Delta f$ = 10 kHz | | 115 | - | - | dBc/√Hz |
| $I_{i(ext)(min)(M)}$ | peak minimum external input current | square wave signal | [1] | - | - | 200 | µA |
| $I_{i(ext)(max)(M)}$ | peak maximum external input current | square wave signal | [1] | 750 | - | - | µA |
| $I_{cm(ext)}$ | external common-mode current | from each pin to GND | | –50 | - | +50 | µA |
| $R_i$ | input resistance | | | - | 5 | 10 | Ω |
| $V_{cm}$ | common-mode voltage | measured between each pin to GND | | 1.0 | 1.2 | 1.4 | V |
| **Tuning system; see Table 28, Table 29, Table 30 and Table 31** | | | | | | | |
| Voltage controlled oscillator | | | | | | | |
| $f_{VCO(min)}$ | minimum VCO frequency | | [2] | - | - | 130 | MHz |
| | | application according to Figure 25 | [2] | - | - | 159.9 | MHz |
| $f_{VCO(max)}$ | maximum VCO frequency | | [2] | 256 | - | - | MHz |
| C/N | carrier-to-noise ratio | $f_{VCO}$ = 200 MHz; $\Delta f$ = 10 kHz; Q = 30 | | 94 | 98 | - | dBc/√Hz |



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**Table 36. Dynamic characteristics** *...continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| Δf | frequency deviation | caused by ripple on supply voltage; $f_{ripple}$ = 100 Hz; $V_{CC(ripple)}$ = 50 mV (RMS); $f_{VCO}$ = 200 MHz; standard FM | - | 2 | - | Hz |
| Charge pump: pin CPOUT; see Table 30 | | | | | | |
| $I_{sink(CP1)}$ | CP1 sink current | $V_{CPOUT}$ = 0.5 V to $V_{CC(PLL)}$ − 1.3 V | 130 | 180 | 240 | µA |
| $I_{source(CP1)}$ | CP1 source current | $V_{CPOUT}$ = 0.5 V to $V_{CC(PLL)}$ − 1.3 V | −240 | −180 | −130 | µA |
| $I_{sink(CP2)}$ | CP2 sink current | $V_{CPOUT}$ = 0.7 V to $V_{CC(PLL)}$ − 1.5 V | 270 | 360 | 480 | µA |
| $I_{source(CP2)}$ | CP2 source current | $V_{CPOUT}$ = 0.7 V to $V_{CC(PLL)}$ − 1.5 V | −480 | −360 | −270 | µA |
| $I_{sink(CP3)}$ | CP3 sink current | $V_{CPOUT}$ = 0.7 V to $V_{CC(PLL)}$ − 0.7 V | 580 | 780 | 1050 | µA |
| $I_{source(CP3)}$ | CP3 source current | $V_{CPOUT}$ = 0.7 V to $V_{CC(PLL)}$ − 0.7 V | −1050 | −780 | −580 | µA |
| $I_{sink(CP4)}$ | CP4 sink current | $V_{CPOUT}$ = 0.7 V to $V_{CC(PLL)}$ − 0.7 V | 1040 | 1400 | 1900 | µA |
| $I_{source(CP4)}$ | CP4 source current | $V_{CPOUT}$ = 0.7 V to $V_{CC(PLL)}$ − 0.7 V | −1900 | −1400 | −1040 | µA |
| $I_{sink(CP5)}$ | CP5 sink current | $V_{CPOUT}$ = 0.7 V to $V_{CC(PLL)}$ − 0.7 V | 1630 | 2200 | 2970 | µA |
| $I_{source(CP5)}$ | CP5 source current | $V_{CPOUT}$ = 0.7 V to $V_{CC(PLL)}$ − 0.7 V | −2970 | −2200 | −1630 | µA |
| Charge pump: pin VTUNE | | | | | | |
| $I_{o(sink)}$ | output sink current | $V_{tune}$ = 0.9 V to $V_{CC(PLL)}$ − 0.7 V | 2070 | 2800 | 3780 | µA |
| $I_{o(source)}$ | output source current | $V_{tune}$ = 0.9 V to $V_{CC(PLL)}$ − 0.7 V | −3780 | −2800 | −2070 | µA |
| Timings | | | | | | |
| $t_{tune}$ | tuning time | Europe FM and US FM band; $f_{ref}$ = 100 kHz; $f_{RF}$ = 87.5 MHz to 108 MHz | - | 0.75 | 1 | ms |
| | | AM MW band; $f_{ref}$ = 20 kHz; $f_{RF}$ = 0.53 MHz to 1.7 MHz | - | - | 10 | ms |
| $t_{upd(AF)}$ | AF update time | cycle time for inaudible AF update including 1 ms mute start and 1 ms mute release time | - | 6 | 6.5 | ms |
| **Antenna Digital Auto Alignment (DAA)** | | | | | | |
| DAA1: pin DAAOUT1[3] | | | | | | |
| $G_{conv(DAA)}$ | DAA conversion gain | | 0.1 | - | 2 | |



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**Table 36. Dynamic characteristics** *…continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_o$ | output voltage | FM mode; DAASW = 0 | | | | |
| | | minimum value | - | - | 0.6 | V |
| | | maximum value | $V_{CC(PLL)}$ – 0.6 | - | - | V |
| | | FM mode; DAASW = 1; independent of tuning voltage | | | | |
| | | minimum value; data byte DAA bits DAA[6:0] = 000 0000 | - | - | 0.6 | V |
| | | maximum value; data byte DAA bits DAA[6:0] = 111 1111 | $V_{CC(PLL)}$ – 0.6 | - | - | V |
| | | AM mode; independent of tuning voltage | | | | |
| | | minimum value; data byte DAA bits DAA[6:0] = 000 0000 | - | - | 0.6 | V |
| | | maximum value; data byte DAA bits DAA[6:0] = 111 1111 | $V_{CC(PLL)}$ – 0.6 | - | - | V |
| $V_{n(o)}$ | output noise voltage | data byte DAA bits DAA[6:0] = 100 0000; FM mode; $V_{tune}$ = 4 V with frequency range from 300 Hz to 22 kHz | - | 30 | 100 | µV |
| $\Delta V_{o(T)}$ | output voltage deviation over temperature | $T_{amb}$ = –40 °C to +85 °C; data byte DAA bits DAA[6:0] = 100 0000 | –30 | - | +30 | mV |
| $\Delta V_{o(step)}$ | step output voltage tolerance | n = 0 to 127; FM mode; $V_{tune}$ = 4 V | $–0.5V_{LSB}$ | 0 | $+0.5V_{LSB}$ | |
| $\Delta V_o$ | output voltage deviation | $V_{tune}$ = 4 V; $I_{load}$ = 50 µA | $–V_{LSB}$ | - | $+V_{LSB}$ | |
| | | $V_{tune}$ = 4 V; $I_{load}$ = –50 µA | $–V_{LSB}$ | - | $+V_{LSB}$ | |
| $t_{s(o)}$ | output settling time | $V_{DAAOUT1}$ = 0.2 V to 8.25 V; $C_L$ = 270 pF | - | 30 | 60 | µs |
| $\alpha_{ripple}$ | ripple rejection | $V_{CC(ripple)}/V_o$; data byte DAA bits DAA[6:0] = 101 0101; FM mode; $V_{tune}$ = 4 V; $f_{ripple}$ = 100 Hz; $V_{CC(ripple)}$ = 100 mV | - | 40 | - | dB |
| DAA2: pin DAAOUT2[4] | | | | | | |
| $G_{conv(DAA)}$ | DAA conversion gain | | 0.7 | - | 1.35 | |
| $V_o$ | output voltage | AM mode and FM mode | | | | |
| | | minimum value | - | - | 0.6 | V |
| | | maximum value | $V_{CC(PLL)}$ – 0.8 | - | - | V |
| $V_{n(o)}$ | output noise voltage | data byte AGC bits SDAA[3:0] = 1000; FM mode; $V_{DAAOUT1}$ = 4 V with frequency range from 300 Hz to 22 kHz | - | 30 | 100 | µV |



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**Table 36. Dynamic characteristics** *…continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $\Delta V_{o(T)}$ | output voltage deviation over temperature | $T_{amb}$ = −40 °C to +85 °C; data byte AGC bits SDAA[3:0] = 1000 | −30 | - | +30 | mV |
| $\Delta V_{o(step)}$ | step output voltage tolerance | n = 0 to 15; FM mode; $V_{DAAOUT1}$ = 4 V | $-0.5V_{LSB}$ | 0 | $+0.5V_{LSB}$ | |
| $\Delta V_o$ | output voltage deviation | $V_{DAAOUT1}$ = 4 V; $I_{load}$ = 50 µA | $-V_{LSB}$ | - | $+V_{LSB}$ | |
| | | $V_{DAAOUT1}$ = 4 V; $I_{load}$ = −50 µA | $-V_{LSB}$ | - | $+V_{LSB}$ | |
| $t_{s(o)}$ | output settling time | $V_{DAAOUT1}$ = 4 V; $V_{DAAOUT2}$ = 2.8 V to 5.4 V; $C_L$ = 270 pF | - | 20 | 30 | µs |
| $\alpha_{ripple}$ | ripple rejection | $V_{CC(ripple)}/V_{DAAOUT1}$; data byte AGC bits SDAA[3:0] = 1010; FM mode; $V_{DAAOUT1}$ = 4 V; $f_{ripple}$ = 100 Hz; $V_{CC(ripple)}$ = 100 mV | - | 50 | - | dB |
| **AM channel** | | | | | | |
| AM RF AGC wideband detector (average detector): pin LNAOUT | | | | | | |
| $V_{LNAOUT(RMS)}$ | RMS voltage on pin LNAOUT | start level of wideband AGC; $R_L$ = 430 Ω (load at pin LNAOUT); m = 0.3; see Table 24 and Table 25 | | | | |
| | | data byte AGC bits WBAGC[1:0] = 00 | 175 | 250 | 350 | mV |
| | | data byte AGC bits WBAGC[1:0] = 01 | 140 | 200 | 280 | mV |
| | | data byte AGC bits WBAGC[1:0] = 10 | 105 | 150 | 210 | mV |
| | | data byte AGC bits WBAGC[1:0] = 11 | 49 | 70 | 98 | mV |
| AM RF AGC narrow-band detector: pins IFOUT1 and IFOUT2 | | | | | | |
| $V_{o(IFOUT)(M)}$ | peak output voltage between pin IFOUT1 and pin IFOUT2 | start level of narrow-band AGC; data byte CONTROL bit IFGAIN = 0; $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = LOW; see Table 15 | | | | |
| | | data byte CONTROL bits NBAGC[1:0] = 00 | 490 | 700 | 980 | mV |
| | | data byte CONTROL bits NBAGC[1:0] = 01 | 390 | 560 | 780 | mV |
| | | data byte CONTROL bits NBAGC[1:0] = 10 | 315 | 450 | 630 | mV |
| | | data byte CONTROL bits NBAGC[1:0] = 11 | 245 | 350 | 490 | mV |
| AM LNA and AGC | | | | | | |
| *Input: pin LNAIN; output: pin LNAOUT* | | | | | | |
| $R_i$ | input resistance | | 0.9 | 1.3 | 1.8 | MΩ |



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**Table 36. Dynamic characteristics** *…continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $C_i$ | input capacitance | | | - | 46 | 69 | pF |
| $G_m$ | transconductance gain | $I_o/V_i$ | | 40 | 57 | 81 | mA/V |
| $\Delta G_{m(T)}$ | transconductance gain deviation over temperature | $T_{amb}$ = −40 °C to +85 °C; see Figure 19 | | - | - | - | dB |
| IP3 | third-order intercept point | $R_L$ = 430 Ω (load at pin LNAOUT) | | 111 | 114 | - | dBµV |
| IP2 | second-order intercept point | $R_L$ = 430 Ω (load at pin LNAOUT) | | 120 | 129 | - | dBµV |
| $V_{n(i)(eq)}$ | equivalent input noise voltage | $C_{source}$ = 110 pF; $R_L$ = 430 Ω (load at pin LNAOUT) | | | | | |
| | | $f_{RF}$ = 1 MHz | | - | 1.0 | 1.4 | nV/√Hz |
| | | $f_{RF}$ = 144 kHz | | - | 2.3 | 3.2 | nV/√Hz |
| $R_o$ | output resistance | | | 80 | 115 | 165 | Ω |
| $C_o$ | output capacitance | in series with output resistance | | - | 22 | 33 | pF |
| $V_{o(p-p)(max)}$ | maximum peak-to-peak output voltage | | | - | 2.2 | - | V |
| $\Delta G_{AGC}$ | AGC gain range | | | 8 | 11 | 14 | dB |
| RF PIN diode AGC current generator output: pin IAMAGC | | | | | | | |
| $\Delta G_{AGC}$ | AGC gain range | $f_{RF}$ = 1 MHz; dummy aerial 15 pF/60 pF | | - | 50 | - | dB |
| $V_{IAMAGC}$ | voltage on pin IAMAGC | PIN diode drive DC voltage | | 2.2 | - | $V_{CCA}$ | V |
| $I_{sink(max)}$ | maximum sink current | $V_{IAMAGC}$ = 2.2 V | [5] | 10 | - | - | mA |
| $I_{sink}$ | sink current | FM mode; data byte DAA bit AGCSW = 1 | | 0.6 | 0.9 | 1.4 | mA |
| | | FM mode; data byte DAA bit AGCSW = 0 | | - | - | 100 | nA |
| AM mixer (IF = 10.7 MHz) | | | | | | | |
| *Mixer input: pins AMMIXIN and AMMIXDEC* | | | | | | | |
| $R_i$ | input resistance | | [6] | 40 | - | - | kΩ |
| $C_i$ | input capacitance | | [6] | - | 3 | 4.5 | pF |
| $V_{i(max)}$ | maximum input voltage | on pin AMMIXIN; 1 dB compression point of $V_{MIXOUT1-MIXOUT2}$; m = 0 | | 500 | - | - | mV |
| *Mixer output: pins AMMIXOUT1 and AMMIXOUT2* | | | | | | | |
| $R_o$ | output resistance | | [7] | 100 | - | - | kΩ |
| $C_o$ | output capacitance | | [7] | - | 4 | 7 | pF |
| $V_{o(p-p)(max)}$ | maximum peak-to-peak output voltage | | | 12 | 15 | - | V |
| $G_{m(conv)}$ | conversion transconductance gain | $I_o/V_i$ | | 1.8 | 2.4 | 3.2 | mA/V |



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**Table 36. Dynamic characteristics** *…continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $\Delta G_{m(conv)(T)}$ | conversion transconductance gain deviation over temperature | $T_{amb}$ = −40 °C to +85 °C; see Figure 20 | - | - | - | dB |
| IP3 | third-order intercept point | $R_L$ = 2.6 kΩ (AC load between output pins); Δf = 300 kHz | 135 | 138 | - | dBµV |
| IP2 | second-order intercept point | $R_L$ = 2.6 kΩ (AC load between output pins) | - | 170 | - | dBµV |
| $V_{n(i)(eq)}$ | equivalent input noise voltage | band limited noise; $R_{source}$ = 750 Ω; noise of $R_{source}$ included; $R_L$ = 2.6 kΩ (AC load between output pins) | - | 7.2 | 10 | nV/√Hz |
| NF | noise figure | | - | 6.2 | 9 | dB |
| **FM channel** | | | | | | |
| FM RF AGC (FM distance mode; data byte AGC bit LODX = 0) | | | | | | |
| *Input: pins FMMIXIN1 and FMMIXIN2*[8] | | | | | | |
| $V_{i(FMMIXIN)(RMS)}$ | RMS input voltage between pin FMMIXIN1 and pin FMMIXIN2 | start level of wideband AGC; keyed AGC off; data byte AGC bit KAGC = 0; see Table 24 and Table 25 | | | | |
| | | data byte AGC bits WBAGC[1:0] = 11 | 5 | 9 | 15 | mV |
| | | data byte AGC bits WBAGC[1:0] = 10 | 7 | 12 | 19 | mV |
| | | data byte AGC bits WBAGC[1:0] = 01 | 10 | 17 | 27 | mV |
| | | data byte AGC bits WBAGC[1:0] = 00 | 14 | 24 | 38 | mV |
| | | start level of wideband AGC; keyed AGC on; data byte AGC bit KAGC = 1; $V_{KAGC} > V_{th(KAGC)}$ | | | | |
| | | data byte AGC bits WBAGC[1:0] = 11 | 19 | 30 | 48 | mV |
| | | data byte AGC bits WBAGC[1:0] = 10 | 21 | 33 | 52 | mV |
| | | data byte AGC bits WBAGC[1:0] = 01 | 24 | 38 | 60 | mV |
| | | data byte AGC bits WBAGC[1:0] = 00 | 28 | 45 | 71 | mV |


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**Table 36. Dynamic characteristics** *…continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| FM RF AGC narrow-band detector: pins IFOUT1 and IFOUT2 | | | | | | |
| $V_{o(IFOUT)(M)}$ | peak output voltage between pin IFOUT1 and pin IFOUT2 | start level of narrow-band AGC; data byte CONTROL bit IFGAIN = 0; $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = LOW; see Table 15 | | | | |
| | | data byte CONTROL bits NBAGC[1:0] = 00 | 490 | 700 | 980 | mV |
| | | data byte CONTROL bits NBAGC[1:0] = 01 | 390 | 560 | 780 | mV |
| | | data byte CONTROL bits NBAGC[1:0] = 10 | 315 | 450 | 630 | mV |
| | | data byte CONTROL bits NBAGC[1:0] = 11 | 245 | 350 | 490 | mV |
| *PIN diode drive output: pin IFMAGC* | | | | | | |
| $I_{source(max)}$ | maximum source current | $V_{TFMAGC} = V_{IFMAGC}$ + 1.4 V; data byte AGC bit KAGC = 0 | –16 | –10 | –7 | mA |
| $I_{sink(max)}$ | maximum sink current | at AGC decay; $V_{TFMAGC} = V_{IFMAGC}$; data byte AGC bit KAGC = 0 | 7 | 10 | 16 | mA |
| $I_{source}$ | source current | AM mode; data byte DAA bit AGCSW = 1 | - | –1.2 | - | mA |
| | | AM mode; data byte DAA bit AGCSW = 0 | - | 0 | - | mA |
| | | data byte AGC bit LODX = 1 (FM local) | –0.75 | –0.5 | –0.35 | mA |
| $V_{IFMAGC}$ | voltage on pin IFMAGC | voltage at PIN diode drive output; $V_{FMMIXIN1} < V_{th}$ | - | 100 | 300 | mV |
| $V_{th(KAGC)}$ | threshold voltage on pin KAGC | threshold level voltage for narrow-band AGC (keyed AGC); data byte AGC bit KAGC = 1; see Table 15 and Table 23 | 500 | 950 | 1400 | mV |
| FM mixer (IF = 10.7 MHz) | | | | | | |
| *FM RF input: pins FMMIXIN1 and FMMIXIN2*[8] | | | | | | |
| $V_{i(RF)(max)}$ | maximum RF input voltage | 1 dB compression point of FM mixer output voltage | 75 | 100 | - | mV |
| $V_{n(i)(eq)}$ | equivalent input noise voltage | $R_{source}$ = 500 Ω; noise of $R_{source}$ included; $R_L$ = 2.6 kΩ (on output pins FMMIXOUT1 and FMMIXOUT2) | | | | |
| | | RFGAIN = 0 | - | 3.7 | 5.2 | nV/√Hz |
| | | RFGAIN = 1 | - | 3 | - | nV/√Hz |
| $R_i$ | input resistance | RFGAIN = 0 | 3 | 3.8 | 4.7 | kΩ |
| | | RFGAIN = 1 | 1.6 | 2.0 | 2.5 | kΩ |



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**Table 36. Dynamic characteristics** *...continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $C_i$ | input capacitance | | - | 2 | 4 | pF |
| $G_{m(conv)}$ | conversion transconductance gain | $I_o/V_i$; RF gain 1; data byte PLLM bit RFGAIN = 0 | 12 | 18 | 25 | mA/V |
| | | $I_o/V_i$; RF gain 2; data byte PLLM bit RFGAIN = 1 | 24 | 36 | 50 | mA/V |
| $\Delta G_{m(conv)(T)}$ | conversion transconductance gain deviation over temperature | $T_{amb}$ = −40 °C to +85 °C; see Figure 21 | - | - | - | dB |
| NF | noise figure | $R_{source}$ = 500 Ω; $T_{amb}$ = 25 °C | | | | |
| | | RFGAIN = 0 | - | 3.5 | 5 | dB |
| | | RFGAIN = 1 | - | 3 | 4.5 | dB |
| IP3 | third-order intercept point | RFGAIN = 0 | 117 | 123 | - | dBµV |
| | | RFGAIN = 1 | 108 | 114 | - | dBµV |
| IRR | image rejection ratio | $V_{o(wanted)}/V_{o(image)}$; $f_{RF(wanted)}$ = 87.5 MHz; $f_{RF(image)}$ = 108.9 MHz | 25 | 40 | - | dB |
| *Output: pins FMMIXOUT1 and FMMIXOUT2*[9] | | | | | | |
| $R_o$ | output resistance | | 100 | - | - | kΩ |
| $C_o$ | output capacitance | | - | 4 | 6 | pF |
| $V_{o(p-p)(max)}$ | maximum peak-to-peak output voltage | | 4.5 | 5.6 | - | V |
| *FM weather band input: pins WXMIXIN and WXMIXDEC* | | | | | | |
| $G_{m(conv)}$ | conversion transconductance gain | $I_o/V_i$ | 10 | 15 | 21 | mA/V |
| $\Delta G_{m(conv)(T)}$ | conversion transconductance gain deviation over temperature | $T_{amb}$ = −40 °C to +85 °C; see Figure 22 | - | - | - | dB |
| $R_i$ | input resistance | | - | 5.1 | - | kΩ |
| $C_i$ | input capacitance | | - | 2 | 4 | pF |
| NF | noise figure | $R_{source}$ = 300 Ω | - | 3.5 | 5 | dB |
| IP3 | third-order intercept point | | - | 116 | - | dBµV |
| IRR | image rejection ratio | $V_{o(wanted)}/V_{o(image)}$; $f_{RF(wanted)}$ = 162.475 MHz; $f_{RF(image)}$ = 183.875 MHz | 20 | 33 | - | dB |
| **IF AGC amplifier** | | | | | | |
| AM mode; inputs: pins AMIFAGCIN and IFAGCDEC[10]; outputs: pins IFOUT1 and IFOUT2[11] | | | | | | |
| $R_i$ | input resistance | | - | 100 | - | kΩ |
| $C_i$ | input capacitance | | - | 5 | 7 | pF |
| $R_o$ | output resistance | | 120 | 210 | 290 | Ω |



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**Table 36. Dynamic characteristics** *…continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| G | gain | data byte CONTROL bit IFGAIN = 0 | | | | |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | 21.2 | 24.2 | 27.2 | dB |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = HIGH | 15.2 | 18.2 | 21.2 | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = HIGH | 9.2 | 12.2 | 15.2 | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = LOW | 3.2 | 6.2 | 9.2 | dB |
| | | data byte CONTROL bit IFGAIN = 1 | | | | |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | 27.2 | 30.2 | 33.2 | dB |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = HIGH | 21.2 | 24.2 | 27.2 | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = HIGH | 15.2 | 18.2 | 21.2 | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = LOW | 9.2 | 12.2 | 15.2 | dB |
| NF | noise figure | $R_{source}$ = 300 Ω; data byte CONTROL bit IFGAIN = 0; $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | - | 12.9 | 16 | dB |
| ΔIM3 | third-order intermodulation distance | two output signals at 35 kHz frequency distance; differential output level of 200 mV; data byte CONTROL bit IFGAIN = 0 | | | | |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | 77 | 83 | - | dB |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = HIGH | 77 | 83 | - | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = HIGH | 77 | 83 | - | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = LOW | 74 | 80 | - | dB |


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**Table 36. Dynamic characteristics** *…continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{i(max)(M)}$ | peak maximum input voltage | 1 dB compression point of IF AGC amplifier output voltage; data byte CONTROL bit IFGAIN = 0 | | | | |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | 45 | - | - | mV |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = HIGH | 90 | - | - | mV |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = HIGH | 180 | - | - | mV |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = LOW | 360 | - | - | mV |
| FM mode; inputs: pins FMIFAGCIN1 and IFAGCDEC[12]; outputs: pins IFOUT1 and IFOUT2[11] | | | | | | |
| $R_i$ | input resistance | | - | 330 | - | Ω |
| $C_i$ | input capacitance | | - | 5 | 7 | pF |
| $R_o$ | output resistance | | 120 | 210 | 290 | Ω |
| G | gain | data byte CONTROL bit IFGAIN = 0 | | | | |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | 28 | 31 | 34 | dB |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = HIGH | 22 | 25 | 28 | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = HIGH | 16 | 19 | 22 | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = LOW | 10 | 13 | 16 | dB |
| | | data byte CONTROL bit IFGAIN = 1 | | | | |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | 34 | 37 | 40 | dB |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = HIGH | 28 | 31 | 34 | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = HIGH | 22 | 25 | 28 | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = LOW | 16 | 19 | 22 | dB |
| NF | noise figure | $R_{source}$ = 300 Ω; data byte CONTROL bit IFGAIN = 0; $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | - | 6.9 | 8.5 | dB |
| IP3 | third-order intercept point | data byte CONTROL bit IFGAIN = 0 | 110 | 115 | - | dBµV |



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**Table 36. Dynamic characteristics** *…continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{i(max)(M)}$ | peak maximum input voltage | 1 dB compression point of IF AGC amplifier output voltage; data byte CONTROL bit IFGAIN = 0 | | | | |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | 20 | - | - | mV |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = HIGH | 40 | - | - | mV |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = HIGH | 80 | - | - | mV |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = LOW | 160 | - | - | mV |
| FM mode; inputs: pins FMIFAGCIN2 and IFAGCDEC[13]; outputs: pins IFOUT1 and IFOUT2[11] | | | | | | |
| $R_i$ | input resistance | | - | 330 | - | Ω |
| $C_i$ | input capacitance | | - | 5 | 7 | pF |
| G | gain | data byte CONTROL bit IFGAIN = 0 | | | | |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | 28 | 31 | 34 | dB |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = HIGH | 22 | 25 | 28 | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = HIGH | 16 | 19 | 22 | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = LOW | 10 | 13 | 16 | dB |
| | | data byte CONTROL bit IFGAIN = 1 | | | | |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | 34 | 37 | 40 | dB |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = HIGH | 28 | 31 | 34 | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = HIGH | 22 | 25 | 28 | dB |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = LOW | 16 | 19 | 22 | dB |
| NF | noise figure | $R_{source}$ = 300 Ω; data byte CONTROL bit IFGAIN = 0; $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | - | 6.9 | 8.5 | dB |
| IP3 | third-order intercept point | data byte CONTROL bit IFGAIN = 0 | 110 | 115 | - | dBµV |



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**Table 36. Dynamic characteristics** *…continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{i(max)(M)}$ | peak maximum input voltage | 1 dB compression point of IF AGC amplifier output voltage; data byte CONTROL bit IFGAIN = 0 | | | | |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = LOW | 20 | - | - | mV |
| | | $V_{IFAGCMSB}$ = LOW; $V_{IFAGCLSB}$ = HIGH | 40 | - | - | mV |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = HIGH | 80 | - | - | mV |
| | | $V_{IFAGCMSB}$ = HIGH; $V_{IFAGCLSB}$ = LOW | 160 | - | - | mV |
| **Digital inputs and outputs** | | | | | | |
| Input: pins IFAGCMSB and IFAGCLSB | | | | | | |
| $V_{IL}$ | LOW-level input voltage | | - | - | 0.9 | V |
| $V_{IH}$ | HIGH-level input voltage | | 1.5 | - | - | V |
| Output: pin AFHOLD | | | | | | |
| $I_{sink(max)}$ | maximum sink current | AFHOLD = LOW; $V_o$ = 0.4 V | 1.0 | - | - | mA |
| Output: pin AFSAMPLE | | | | | | |
| $I_{sink(max)}$ | maximum sink current | AFSAMPLE = LOW; $V_o$ = 0.4 V | 1.0 | - | - | mA |
| Output: pin SWPORT | | | | | | |
| $I_{sink(max)}$ | maximum sink current | data byte CONTROL bit FLAG = 1; $V_o$ = 0.4 V | 1.0 | - | - | mA |

[1] Differential current on pins FREF1 and FREF2.

[2] The VCO frequency is determined by the external circuit at pins OSCFDB and OSCTNK.

[3] Conversion gain formula of DAA1: $V_{DAAOUT1} = \left(1.915 \times \frac{n}{128} + 0.1\right) \times V_{tune}$ where n = 0 to 127.

[4] Conversion gain formula of DAA2: $V_{DAAOUT2} = \left(0.693 \times \frac{n}{16} + 0.7\right) \times V_{DAAOUT1}$ where n = 0 to 15.

[5] The sink current must be limited to 18 mA by the external circuit.

[6] Input parameters of AM mixer measured between pins AMMIXIN and AMMIXDEC.

[7] Output parameters of AM mixer measured between pins AMMIXOUT1 and AMMIXOUT2.

[8] Input parameters of FM mixer measured between pins FMMIXIN1 and FMMIXIN2.

[9] Output parameters of FM mixer measured between pins FMMIXOUT1 and FMMIXOUT2.

[10] Input parameters of AM IF amplifier measured between pins AMIFAGCIN and IFAGCDEC.

[11] Output parameters of IF AGC amplifier measured between pins IFOUT1 and IFOUT2.

[12] Input parameters of FM IF amplifier measured between pins FMIFAGCIN1 and IFAGCDEC.

[13] Input parameters of FM IF amplifier measured between pins FMIFAGCIN2 and IFAGCDEC.



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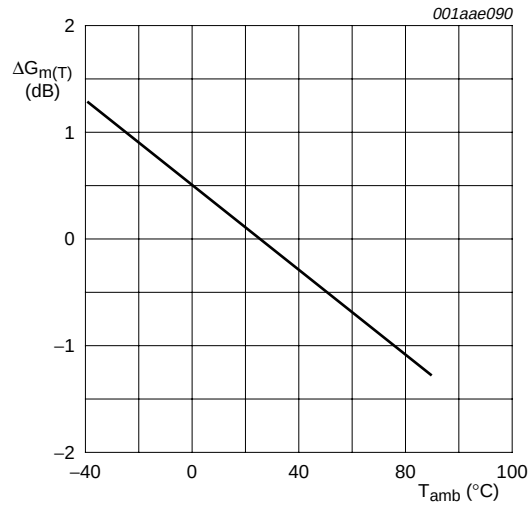



Fig 19. AM LNA transconductance gain deviation over temperature (including application)

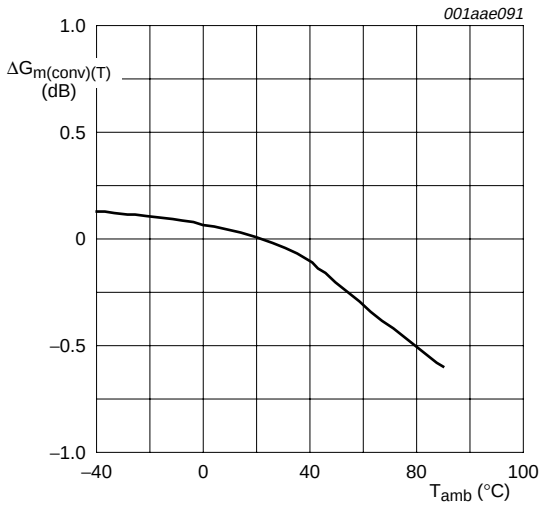



Fig 20. AM mixer conversion transconductance gain deviation over temperature (including application)

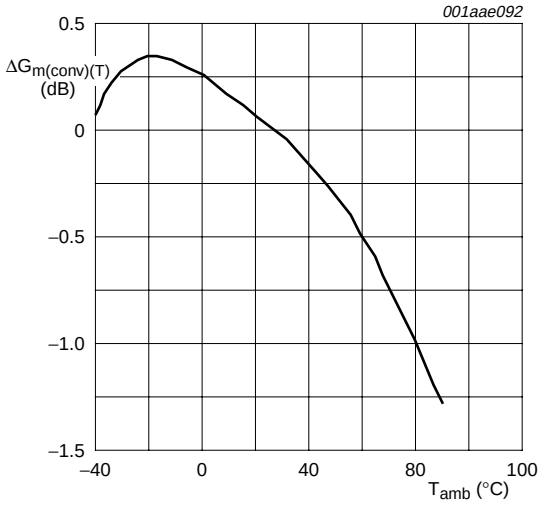



Fig 21. FM mixer conversion transconductance gain deviation over temperature (including application)

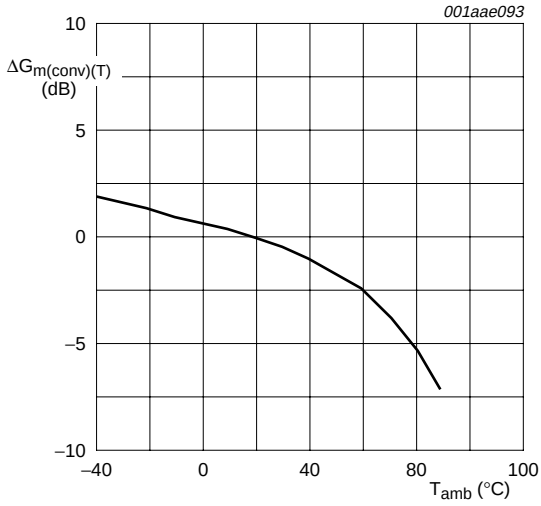



Fig 22. Weather band mixer conversion transconductance gain deviation over temperature (including application)

## 13. I²C-bus characteristics

The TEF6730HW complies with the fast-mode I²C-bus protocol. The maximum I²C-bus communication speed is 400 kbit/s.

SDA and SCL HIGH and LOW internal thresholds are specified according to an I²C-bus voltage range from 2.5 V to 3.3 V including I²C-bus voltage tolerances of ±10 %. The I²C-bus interface tolerates also SDA and SCL signals from a 5 V bus. Restrictions for $V_{IL}$ in a 5 V application can be derived from Table 37.

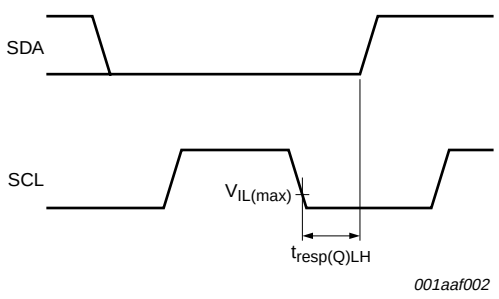

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**Table 37. I²C-bus parameters**

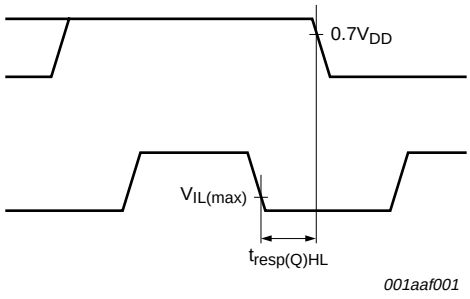
| Symbol | Parameter | Conditions | | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|---|
| $V_{IL}$ | LOW-level input voltage | | | - | - | 1.09 | V |
| $V_{IH}$ | HIGH-level input voltage | | | 1.56 | - | - | V |
| $C_i$ | capacitance for each I/O pin | pin SDA | | - | 4 | 6 | pF |
| | | pin SCL | | - | 3 | 5 | pF |
| $t_{resp(Q)HL}$ | HIGH-to-LOW data output response time | acknowledge and read data; see Figure 23 | | | | | |
| | | $V_{DD}$ = 5 V; I = 3 mA; $C_b$ = 400 pF | | - | 700 | 863 | ns |
| | | $V_{DD}$ = 3.3 V; $R_p$ = 1.8 kΩ; $C_b$ = 400 pF | | - | 570 | 668 | ns |
| | | $V_{DD}$ = 2.5 V; $R_p$ = 35 kΩ; $C_b$ = 10 pF | | - | 520 | 593 | ns |
| $t_{resp(Q)LH}$ | LOW-to-HIGH data output response time | read data; see Figure 23 | | - | 450 | 488 | ns |
| $t_{of}$ | output fall time from $V_{IHmin}$ to $V_{ILmax}$ | $C_b$ = 10 pF to 120 pF; see Figure 24 | [1] | 20 + 0.1$C_b$ | 10 × $V_{DD}$ | - | ns |
| | | $C_b$ ≥ 120 pF; see Figure 24 | [1][2] | 20 + 0.1$C_b$ | - | 250 | ns |

[1] Minimum value of $t_{of}$; $C_b$ = total capacitance of one I²C-bus line [pF].

[2] Typical value of $t_{of}$; the output fall time $t_{of}$ [ns] depends on the total load capacitance $C_b$ [pF] and the I²C-bus voltage $V_{DD}$ [V]: $t_{of} = {}^{1}/_{12} \times V_{DD} \times C_b$.




a. Data change from LOW to HIGH




b. Data change from HIGH to LOW

**Fig 23. Data output response time of the IC**


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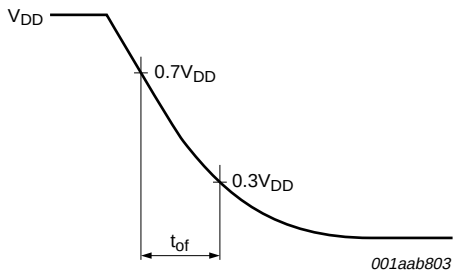



**Fig 24. Definition of the fall time of the output signal**

## 14. Overall system parameters

**Table 38. Overall system parameters**

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **AM overall system parameters[1]** | | | | | | |
| $f_{i(RF)}$ | RF input frequency | LW | 144 | - | 288 | kHz |
| | | MW | 522 | - | 1710 | kHz |
| | | SW | 2.3 | - | 26.1 | MHz |
| $f_{IF}$ | IF frequency | | - | 10.7 | - | MHz |
| $V_{sens}$ | sensitivity voltage | (S+N)/N = 26 dB | - | 50 | - | µV |
| $V_{i(RF)}$ | RF input voltage | start level of wideband AGC | | | | |
| | | data byte AGC bits WBAGC[1:0] = 00 | - | 125 | - | mV |
| | | data byte AGC bits WBAGC[1:0] = 01 | - | 100 | - | mV |
| | | data byte AGC bits WBAGC[1:0] = 10 | - | 75 | - | mV |
| | | data byte AGC bits WBAGC[1:0] = 11 | - | 35 | - | mV |
| $V_{i(RF)M}$ | peak RF input voltage | start level of narrow-band AGC; m = 0 | | | | |
| | | data byte AGC bits NBAGC[1:0] = 00 | - | 200 | - | mV |
| | | data byte AGC bits NBAGC[1:0] = 01 | - | 170 | - | mV |
| | | data byte AGC bits NBAGC[1:0] = 10 | - | 140 | - | mV |
| | | data byte AGC bits NBAGC[1:0] = 11 | - | 115 | - | mV |
| IP2 | second-order intercept point | referenced to receiver input | - | 152 | - | dBµV |
| IP3 | third-order intercept point | referenced to receiver input | | | | |
| | | Δf = 40 kHz | - | 130 | - | dBµV |
| | | Δf = 100 kHz | - | 133 | - | dBµV |
| $\alpha_{ripple}$ | ripple rejection | $V_{CC(ripple)}/V_{audio}$; $f_{ripple}$ = 100 Hz; $V_{CC(ripple)}$ = 10 mV (RMS); $V_{i(RF)}$ = 1 mV to 1 V | - | 40 | - | dB |
| **FM overall system parameters[2]** | | | | | | |
| $f_{i(RF)}$ | RF input frequency | FM standard | 65 | - | 108 | MHz |
| | | weather band | 162.4 | - | 162.55 | MHz |
| $f_{IF}$ | IF frequency | | - | 10.7 | - | MHz |


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**Table 38. Overall system parameters** *…continued*

*$V_{CCA}$ = 8.5 V; $T_{amb}$ = 25 °C; see Figure 25; all AC values are given in RMS; unless otherwise specified.*

| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{sens}$ | sensitivity voltage | $B_{IF}$ = 170 kHz | - | 2 | - | µV |
| | | threshold extension enabled; weak signal handling enabled (SAF7730 N231) | - | 1.1 | - | µV |
| $V_{i(RF)}$ | RF input voltage | start level of wideband AGC | | | | |
| | | data byte AGC bits WBAGC[1:0] = 00 | - | 19 | - | mV |
| | | data byte AGC bits WBAGC[1:0] = 01 | - | 14 | - | mV |
| | | data byte AGC bits WBAGC[1:0] = 10 | - | 10 | - | mV |
| | | data byte AGC bits WBAGC[1:0] = 11 | - | 7 | - | mV |
| $V_{i(RF)M}$ | peak RF input voltage | start level of narrow-band AGC; m = 0 | | | | |
| | | data byte AGC bits NBAGC[1:0] = 00 | - | 17 | - | mV |
| | | data byte AGC bits NBAGC[1:0] = 01 | - | 14 | - | mV |
| | | data byte AGC bits NBAGC[1:0] = 10 | - | 11 | - | mV |
| | | data byte AGC bits NBAGC[1:0] = 11 | - | 9 | - | mV |
| IP3 | third-order intercept point | Δf = 400 kHz | - | 123 | - | dBµV |
| $\alpha_{ripple}$ | ripple rejection | $V_{CC(ripple)}/V_{audio}$; $f_{ripple}$ = 100 Hz; $V_{CC(ripple)}$ = 10 mV (RMS); $V_{i(RF)}$ = 500 µV | - | 64 | - | dB |

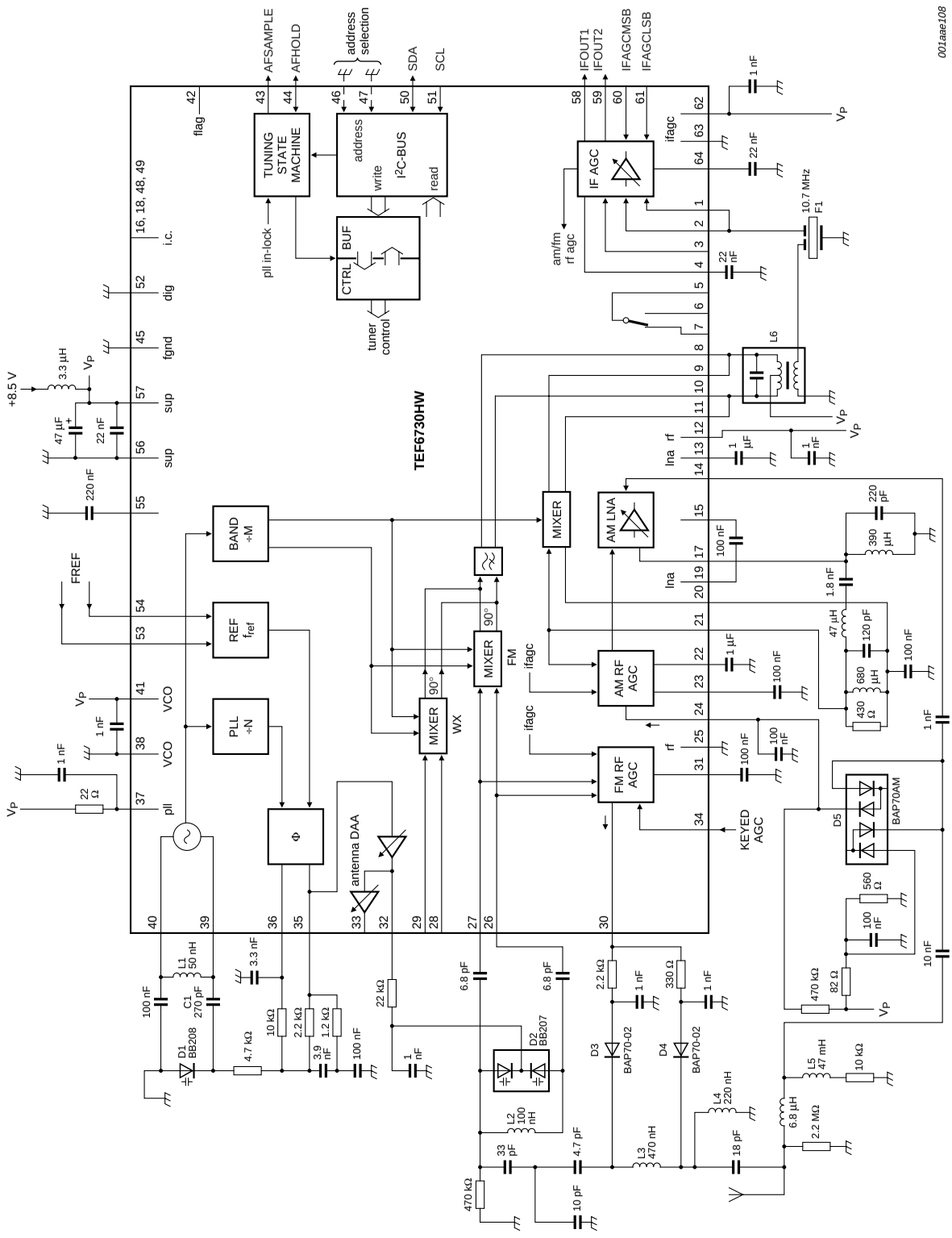
[1] Based on 15 pF/60 pF dummy aerial, voltages at dummy aerial input, $f_{mod}$ = 400 Hz, 2.5 kHz audio bandwidth, $f_{i(RF)}$ = 990 kHz, m = 0.3 and nominal maximum IF AGC gain, unless otherwise specified.

[2] Based on 75 Ω dummy aerial, voltages at dummy aerial input, $f_{mod}$ = 400 Hz, de-emphasis = 50 µs, $f_{i(RF)}$ = 97.1 MHz, Δf = 22.5 kHz, nominal mixer gain and nominal maximum IF AGC gain, unless otherwise specified.



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# 15. Application information




(1) For list of components see Table 39.

**Fig 25. Application diagram of TEF6730HW**



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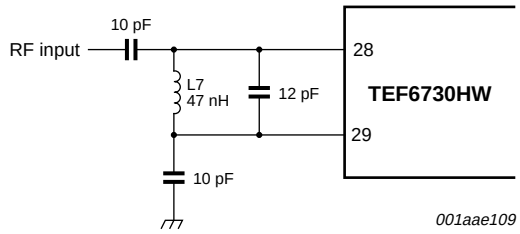



Fig 26. Weather band application

Table 39. List of components of Figure 25 and Figure 26

| Symbol | Component | Type | Manufacturer |
|---|---|---|---|
| C1 | capacitor for VCO tuning | 270 pF; type NP0 | - |
| L1 | VCO coil | 50 nH; E558CNA-100035 | TOKO |
| L2 | FM input coil | 100 nH; C2520C-R10 | Sagami |
| L3 | FM antenna coil | 470 nH; C2520C-R47 | Sagami |
| L4 | FM antenna coil | 220 nH; C2520C-R22 | Sagami |
| L5 | AM mains suppression coil | 47 mH; 388BN-1211Z | TOKO |
| L6 | 10.7 MHz IF coil | PF670CCS-A065DX | TOKO |
| L7 | weather band input coil | 47 nH; LQW31H | MURATA |
| D1 | VCO variable capacitance diode | BB208 | Philips |
| D2 | FM RF selectivity variable capacitance diode | BB207 | Philips |
| D3 | FM PIN diode | BAP70-02 | Philips |
| D4 | FM PIN diode | BAP70-02 | Philips |
| D5 | AM PIN diode | BAP70AM | Philips |
| F1 | 10.7 MHz IF ceramic filter | SFELA10M7HAA0-B0 | MURATA |

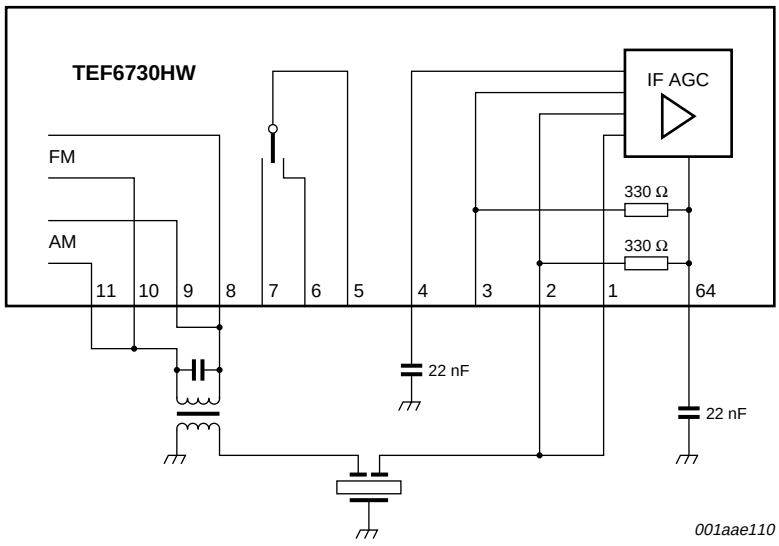



Fig 27. FM and AM mode


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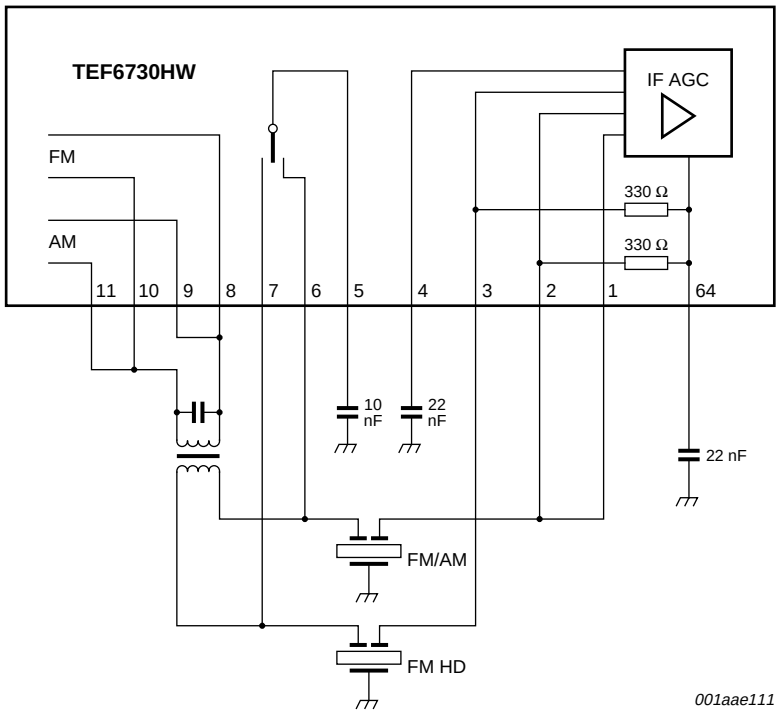



Fig 28. FM/AM and FM HD mode

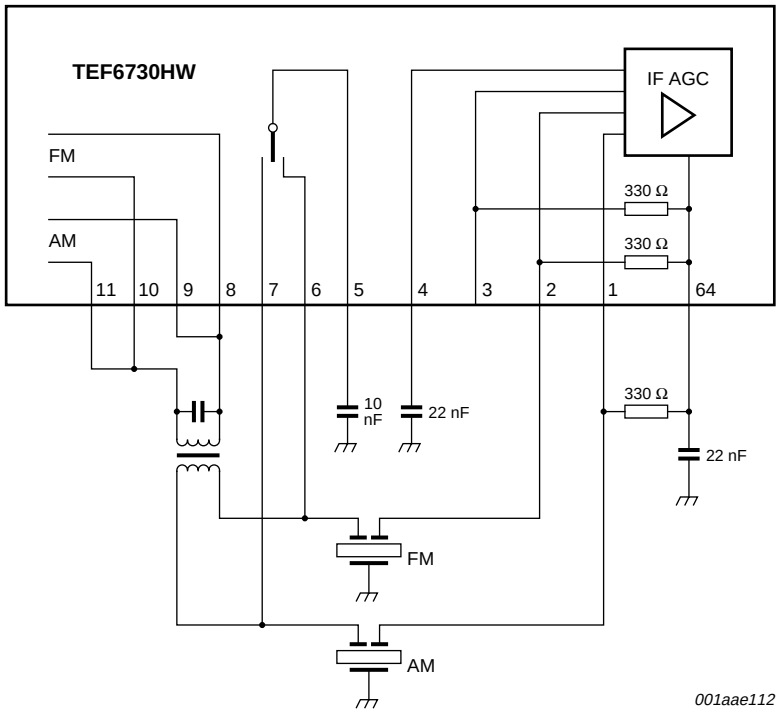



Fig 29. FM and AM (narrow band) mode


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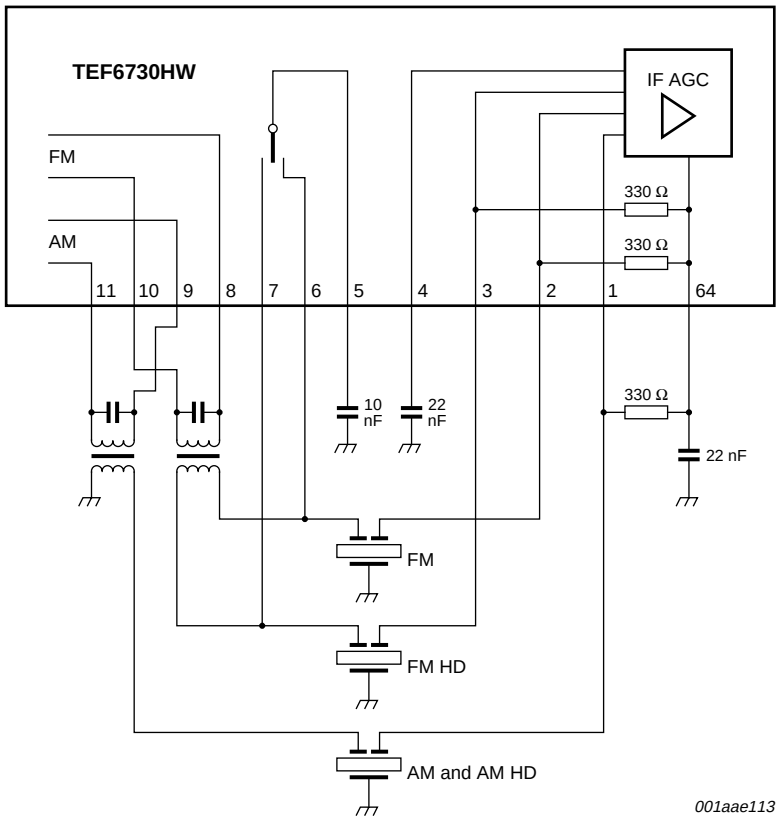


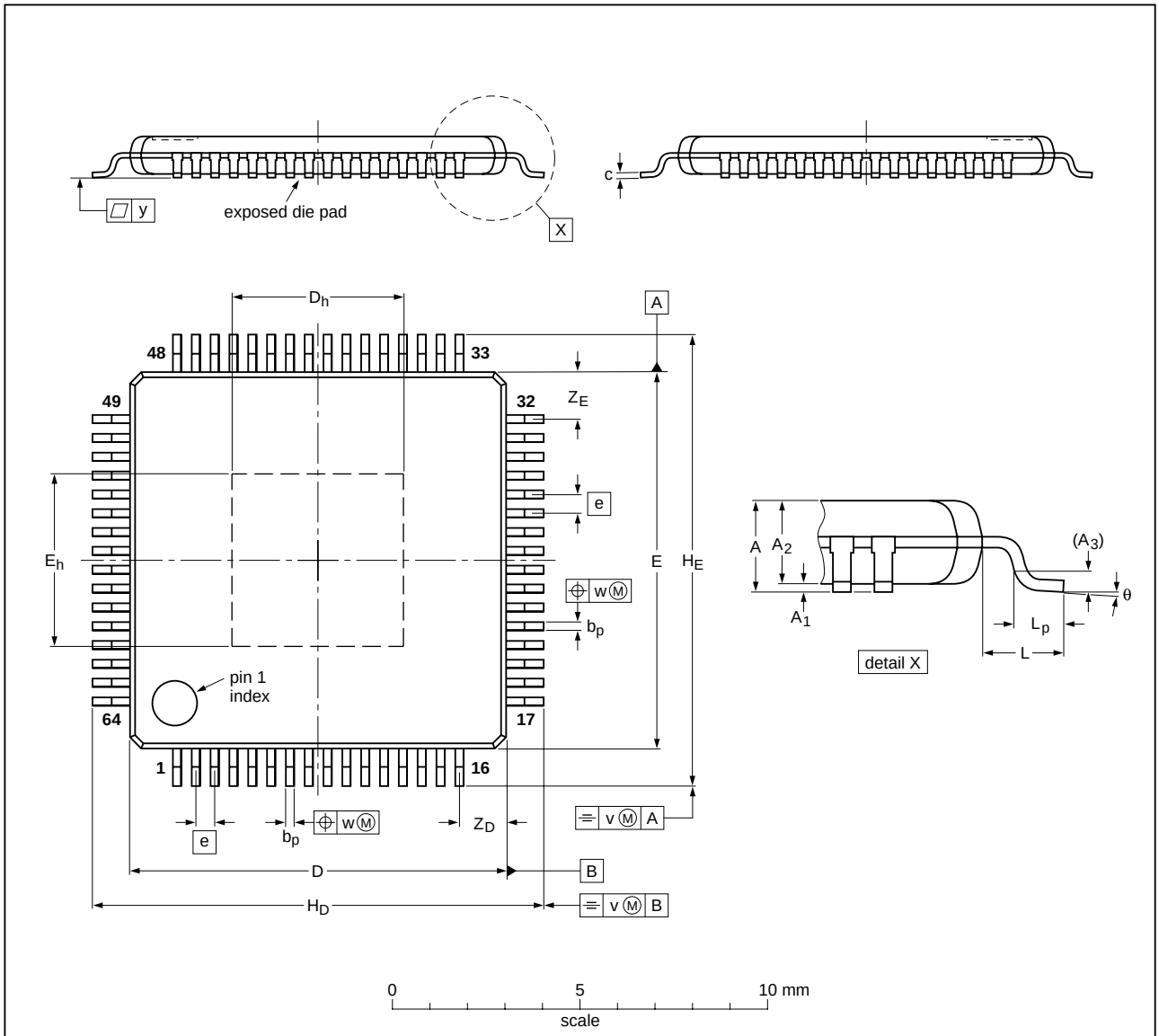

Fig 30. FM, AM, AM HD and FM HD mode



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# 16. Package outline

**HTQFP64: plastic thermal enhanced thin quad flat package; 64 leads; body 10 x 10 x 1 mm; exposed die pad** **SOT855-1**




**DIMENSIONS (mm are the original dimensions)**

| UNIT | A max | $A_1$ | $A_2$ | $A_3$ | $b_p$ | c | $D^{(1)}$ | $D_h$ | $E^{(1)}$ | $E_h$ | e | $H_D$ | $H_E$ | L | $L_p$ | v | w | y | $Z_D^{(1)}$ | $Z_E^{(1)}$ | θ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.2 | 0.12<br>0.05 | 1.05<br>0.95 | 0.25 | 0.27<br>0.17 | 0.18<br>0.12 | 10.1<br>9.9 | 4.7<br>4.5 | 10.1<br>9.9 | 4.7<br>4.5 | 0.5 | 12.15<br>11.85 | 12.15<br>11.85 | 1 | 0.75<br>0.45 | 0.2 | 0.08 | 0.1 | 1.45<br>1.05 | 1.45<br>1.05 | 7°<br>0° |

**Note**

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | JEITA | | | |
| SOT855-1 | | MS-026 | | | | ~~04-05-18~~<br>05-05-11 |

**Fig 31. Package outline SOT855-1 (HTQFP64)**



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# 17. Soldering

## 17.1 Introduction to soldering surface mount packages

There is no soldering method that is ideal for all surface mount IC packages. Wave soldering can still be used for certain surface mount ICs, but it is not suitable for fine pitch SMDs. In these situations reflow soldering is recommended.

## 17.2 Reflow soldering

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement. Driven by legislation and environmental forces the worldwide use of lead-free solder pastes is increasing.

Several methods exist for reflowing; for example, convection or convection/infrared heating in a conveyor type oven. Throughput times (preheating, soldering and cooling) vary between 100 seconds and 200 seconds depending on heating method.

Typical reflow temperatures range from 215 °C to 260 °C depending on solder paste material. The peak top-surface temperature of the packages should be kept below:

**Table 40. SnPb eutectic process - package peak reflow temperatures (from *J-STD-020C* July 2004)**

| Package thickness | Volume $mm^3$ < 350 | Volume $mm^3$ ≥ 350 |
|---|---|---|
| < 2.5 mm | 240 °C + 0/–5 °C | 225 °C + 0/–5 °C |
| ≥ 2.5 mm | 225 °C + 0/–5 °C | 225 °C + 0/–5 °C |

**Table 41. Pb-free process - package peak reflow temperatures (from *J-STD-020C* July 2004)**

| Package thickness | Volume $mm^3$ < 350 | Volume $mm^3$ 350 to 2000 | Volume $mm^3$ > 2000 |
|---|---|---|---|
| < 1.6 mm | 260 °C + 0 °C | 260 °C + 0 °C | 260 °C + 0 °C |
| 1.6 mm to 2.5 mm | 260 °C + 0 °C | 250 °C + 0 °C | 245 °C + 0 °C |
| ≥ 2.5 mm | 250 °C + 0 °C | 245 °C + 0 °C | 245 °C + 0 °C |

Moisture sensitivity precautions, as indicated on packing, must be respected at all times.

## 17.3 Wave soldering

Conventional single wave soldering is not recommended for surface mount devices (SMDs) or printed-circuit boards with a high component density, as solder bridging and non-wetting can present major problems.

To overcome these problems the double-wave soldering method was specifically developed.

If wave soldering is used the following conditions must be observed for optimal results:

- Use a double-wave soldering method comprising a turbulent wave with high upward pressure followed by a smooth laminar wave.
- For packages with leads on two sides and a pitch (e):


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- larger than or equal to 1.27 mm, the footprint longitudinal axis is **preferred** to be parallel to the transport direction of the printed-circuit board;
- smaller than 1.27 mm, the footprint longitudinal axis **must** be parallel to the transport direction of the printed-circuit board.

The footprint must incorporate solder thieves at the downstream end.

- For packages with leads on four sides, the footprint must be placed at a 45° angle to the transport direction of the printed-circuit board. The footprint must incorporate solder thieves downstream and at the side corners.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Typical dwell time of the leads in the wave ranges from 3 seconds to 4 seconds at 250 °C or 265 °C, depending on solder material applied, SnPb or Pb-free respectively.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

## 17.4 Manual soldering

Fix the component by first soldering two diagonally-opposite end leads. Use a low voltage (24 V or less) soldering iron applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C.

When using a dedicated tool, all other leads can be soldered in one operation within 2 seconds to 5 seconds between 270 °C and 320 °C.

## 17.5 Package related soldering information

**Table 42. Suitability of surface mount IC packages for wave and reflow soldering methods**

| Package[1] | Soldering method | |
|---|---|---|
| | Wave | Reflow[2] |
| BGA, HTSSON..T[3], LBGA, LFBGA, SQFP, SSOP..T[3], TFBGA, VFBGA, XSON | not suitable | suitable |
| DHVQFN, HBCC, HBGA, HLQFP, HSO, HSOP, HSQFP, HSSON, HTQFP, HTSSOP, HVQFN, HVSON, SMS | not suitable[4] | suitable |
| PLCC[5], SO, SOJ | suitable | suitable |
| LQFP, QFP, TQFP | not recommended[5][6] | suitable |
| SSOP, TSSOP, VSO, VSSOP | not recommended[7] | suitable |
| CWQCCN..L[8], PMFP[9], WQCCN..L[8] | not suitable | not suitable |

[1] For more detailed information on the BGA packages refer to the *(LF)BGA Application Note* (AN01026); order a copy from your Philips Semiconductors sales office.

[2] All surface mount (SMD) packages are moisture sensitive. Depending upon the moisture content, the maximum temperature (with respect to time) and body size of the package, there is a risk that internal or external package cracks may occur due to vaporization of the moisture in them (the so called popcorn effect). For details, refer to the Drypack information in the *Data Handbook IC26; Integrated Circuit Packages; Section: Packing Methods*.


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[3] These transparent plastic packages are extremely sensitive to reflow soldering conditions and must on no account be processed through more than one soldering cycle or subjected to infrared reflow soldering with peak temperature exceeding 217 °C ± 10 °C measured in the atmosphere of the reflow oven. The package body peak temperature must be kept as low as possible.

[4] These packages are not suitable for wave soldering. On versions with the heatsink on the bottom side, the solder cannot penetrate between the printed-circuit board and the heatsink. On versions with the heatsink on the top side, the solder might be deposited on the heatsink surface.

[5] If wave soldering is considered, then the package must be placed at a 45° angle to the solder wave direction. The package footprint must incorporate solder thieves downstream and at the side corners.

[6] Wave soldering is suitable for LQFP, QFP and TQFP packages with a pitch (e) larger than 0.8 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.65 mm.

[7] Wave soldering is suitable for SSOP, TSSOP, VSO and VSSOP packages with a pitch (e) equal to or larger than 0.65 mm; it is definitely not suitable for packages with a pitch (e) equal to or smaller than 0.5 mm.

[8] Image sensor packages in principle should not be soldered. They are mounted in sockets or delivered pre-mounted on flex foil. However, the image sensor package can be mounted by the client on a flex foil by using a hot bar soldering process. The appropriate soldering profile can be provided on request.

[9] Hot bar soldering or manual soldering is suitable for PMFP packages.


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## 18. Footprint for soldering

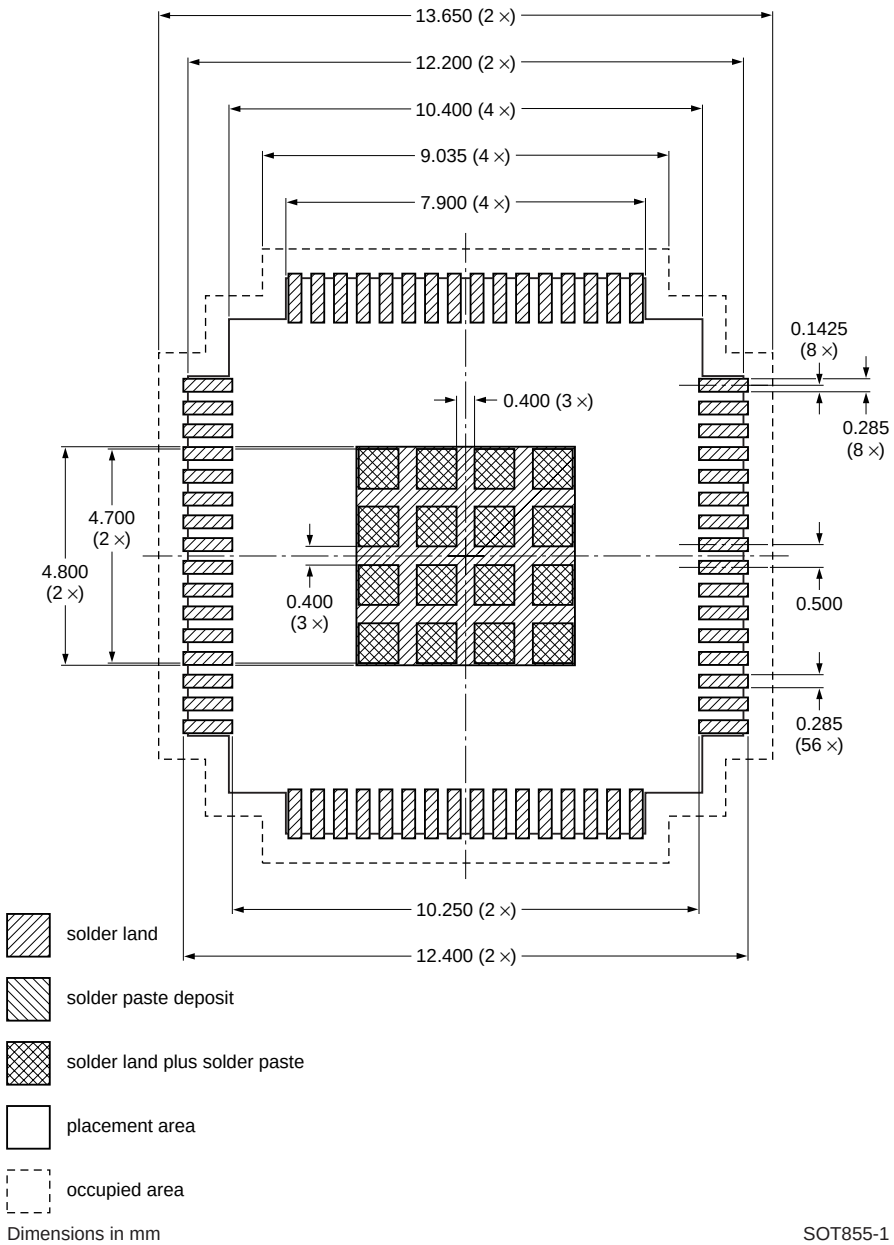



**Fig 32. Footprint**



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# 19. Abbreviations

Table 43. Abbreviations

| Acronym | Description |
|---|---|
| ADC | Analog-to-Digital Converter |
| AF | Alternative Frequency |
| AFU | Alternative Frequency Updating |
| AGC | Automatic Gain Control |
| DAA | Digital Auto Alignment |
| DSP | Digital Signal Processor |
| DX | Distance |
| HD | High Definition |
| IF | Intermediate Frequency |
| LNA | Low Noise Amplifier |
| LO | Local Oscillator |
| LSB | Least Significant Bit |
| LW | Long Wave |
| MSB | Most Significant Bit |
| MW | Medium Wave |
| PLL | Phase-Locked Loop |
| RF | Radio Frequency |
| SCL | Serial Clock |
| SDA | Serial Data |
| SW | Short Wave |
| VCO | Voltage-Controlled Oscillator |
| WB | Weather Band |

# 20. Revision history

Table 44. Revision history

| Document ID | Release date | Data sheet status | Change notice | Supersedes |
|---|---|---|---|---|
| TEF6730_1 | 20060710 | Product data sheet | - | - |


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| Document status[1][2] | Product status[3] | Definition |
|---|---|---|
| Objective [short] data sheet | Development | This document contains data from the objective specification for product development. |
| Preliminary [short] data sheet | Qualification | This document contains data from the preliminary specification. |
| Product [short] data sheet | Production | This document contains the product specification. |

[1] Please consult the most recently issued document before initiating or completing a design.

[2] The term 'short data sheet' is explained in section "Definitions".

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